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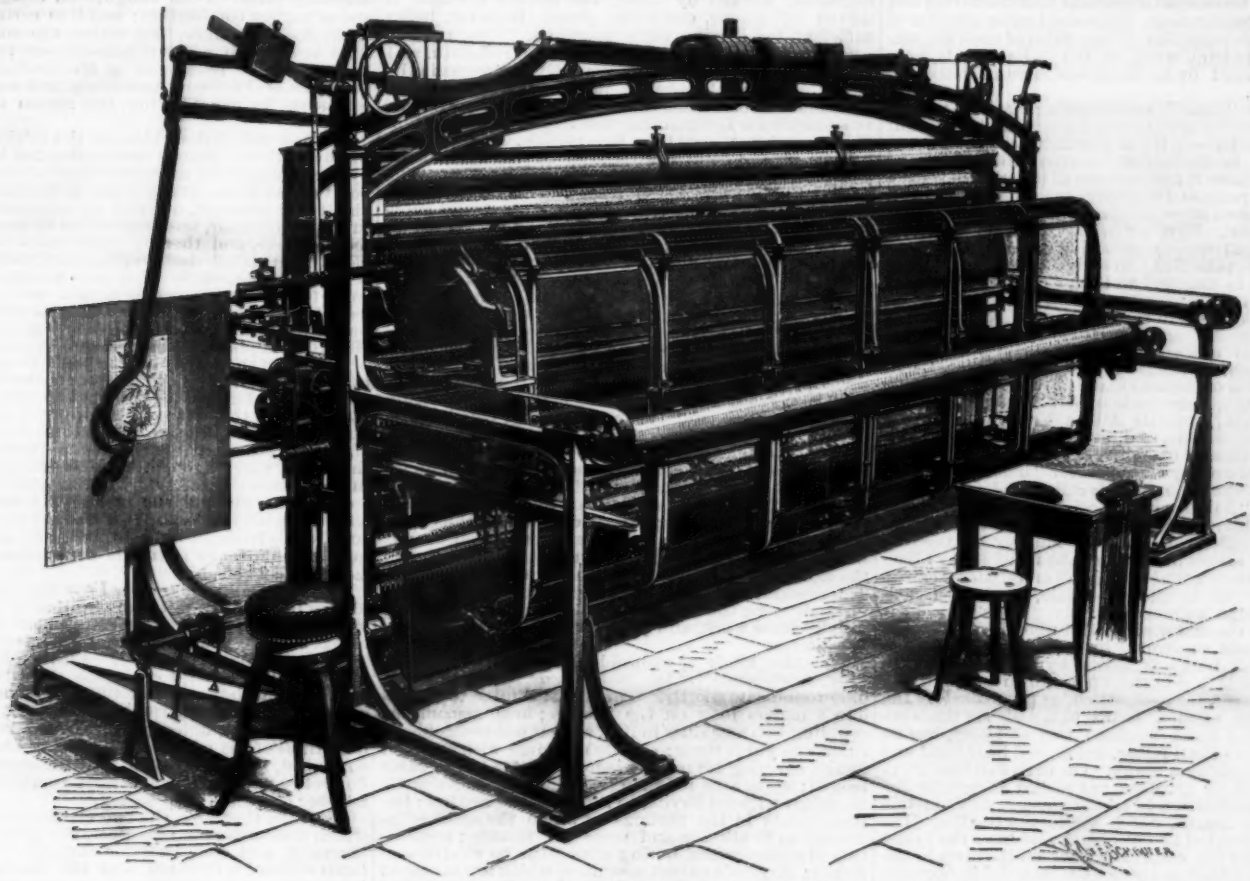
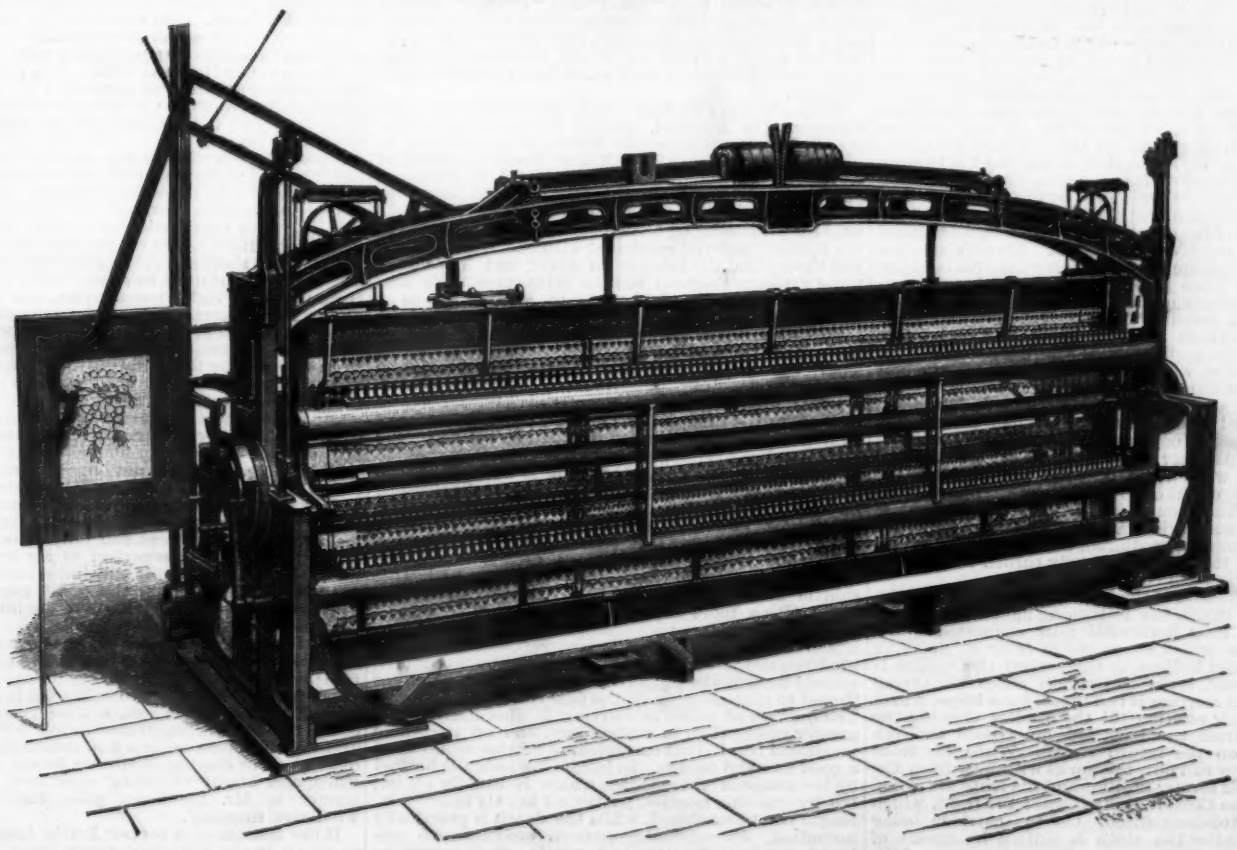
EMBROIDERING MACHINES.

THE SAECHSISCHE STICKMASCHINENFABRIK, VORMALS ALBERT VOIGT.

THE liking for highly ornamented textile fabrics appears to be inherent in mankind, shared as it is by the uncivilized savage and the most refined modern lady, by our remote ancestors and the present generation. Among the means for producing this ornamentation and variety of patterns and colors, embroidery is the most primitive and ancient, and has never lost its hold upon the favor of the public, although at certain periods it played a more prominent part than at present. The Greeks and Romans during classical times possessed only treadle looms, by means of which only very simple patterns in stripes or checks could be produced, and all more elaborate patterns were embroidered. The development of the weaver's art in India and the Levant during the earlier centuries of our era introduced a powerful competition with embroidery, and soon all repetition patterns or such which were not intended to



HAND EMBROIDERING MACHINE.



SHUTTLE EMBROIDERING MACHINE.

produce the effect of embroidery. were woven, and only the finest productions were left to the embroiderer's art, who frequently made use of the already highly ornamented fabrics as a ground on which to trace his further artistic decoration. In the conservative Eastern countries much of this has survived, but in Europe the further improvement in weaving, especially through the invention of the Jacquard machine, and also the perfection attained in fabric printing, have driven embroidery, as a general means of decorating textile fabrics, almost out of the field, and its use may be said to be confined to the occasional decoration of small pieces for domestic or ecclesiastical purposes, with one notable exception. We refer to the embroidery of white fabrics with flat or crewel stitches, chiefly used for underclothing and similar articles which require frequent washing, and for which other ornamentation is unsuitable, or at all events not fashionable. This flat embroidery afforded about the middle of this century occupation to a large number of women, and replaced to some extent the loss they had suffered through the extinction of home spinning. Machine work, however, was not long in invading this field; and although this class of embroidery is frequently made by women as a pastime, it cannot be any longer classed among the remunerative domestic industries, though it has become an important manufacturing one which gives employment to a considerable number of operatives, the reduction in the price of such flat embroidery, or Madeira work, as the ladies call it, having been followed by an enormous increase in its consumption.

The present "hand" embroidering machine was invented in 1829 by an Alsatian, Josua Heilmann, but did not make its way till in 1850 Rittmeyer and Senn, of St. Gallen, in Switzerland, started the industry at that place, where it has still one of its principal seats, about 50,000 persons being engaged in it at present, while the exports of embroidered fabrics are valued at about £4,000,000. Its other principal locality is in the Saxon Vogtland and neighboring districts, and there are minor centers in Belgium and some departments of France, while in England and the United States it is of minor importance.

The machines used in this industry at present are of two sorts—"hand" and "shuttle" machines; and as these machines are comparatively little known and used in England, we think our readers will be interested by a description of them as made at present. We have selected two machines made by the Saechsische Stickmaschinenfabrik, vormals Albert Voigt, who have a good name as makers, and have made many improvements in this class of machinery.

The machine usually employed for "holed" embroidery and fast festoons, or what is called Madeira work, is the flat stitch "hand" machine originated by Helimann, driven by a hand crank, two treadles, and a pantograph guide. According to the number of needles, this machine makes in 12 hours about 700,000 to 1,000,000 stitches, while a practiced hand embroiderer can at most make 15,000 in the same time, so that the machine works 50 to 70 times as quickly. In all embroidering machines the material worked upon is stretched in a vertical frame suspended in the middle of the machine, and this frame is moved by means of a pantograph from side to side and up or down in all directions, and placed for each stitch, as prescribed by the pattern drawn upon a board to a scale six times enlarged. In the hand machine, two carriages, one on each side of the cloth frame, are moved backward and forward by turning a crank. On each carriage 112 to 224 iron tongs or grippers are placed at regular distances from each other, in two or three rows 4·5 meters (14 ft. 9 in.) in length, which guide the needles. The needles are pointed at both ends, and have the eyelet through which the embroidery thread is drawn in the middle, so that they can pierce the material in opposite directions without having to be turned. When by moving the front carriage the threaded needles are carried against the cloth, they pierce it and enter into the jaws of the grippers on the back carriage, which has been moved close to the cloth, on the opposite side, while the grippers are opened by pushing down one of the treadles. By forcing down the other treadle the jaws of all the grippers on the first carriage are opened and the needles released, and at the same time seized by the grippers on the opposite side, so that they are drawn through the cloth by the outward run of the back carriage as far as required to tighten the threads sufficiently. The cloth frame is then shifted by means of the pantograph, as prescribed by the pattern design, so that the correct places of the cloth are brought before the points of the needles, when the action described is repeated in the diverse direction. We may mention here that the designing of embroidery patterns occupies an important place among the industrial arts, over 1,000 persons being employed in it in Switzerland alone.

The original machine has received many improvements besides those referring to detail construction, among which the application of a boring apparatus for piercing the holes, where the pattern requires them, is one of the most important. This consists of rails fixed on hinges, one along each row of needles, and provided with four-edged steel points, which when the rails are turned down stand out centrally with and in front of each needle. Another set of rails are arranged on the back carriage, with a row of holes for receiving the piercers, and brought close to the cloth to prevent its giving way. The front carriage being run in against the cloth, the holes are pierced in the places determined by the pantograph as required, and then edged round. After piercing the rails are simply turned back, when the embroidering can be proceeded with.

For the production of the favorite festoon, banquette, or buttonhole stitch, the festooning motion is applied. It consists of long horizontal rails connected into a movable frame, which are placed in front of the cloth below the needle holders, so that, when the motion is thrown into gear, forks on the rails catch the thread when the front carriage is run in and form loops, which are held in their position till the needles piercing the cloth again from the back side are passed through these loops on the return stroke. When the front carriage is now run out, the forks withdraw from the loops into their former position and the loops are closed by drawing the threads tight toward the front, which forms the buttonhole stitch. On the carriage being run in again after the cloth is shifted by means of the pantograph, the forks are advanced again, and the action of the apparatus repeated.

The shuttle machine, which is principally used for embroidering net or tulle, has recently come into prominence. It produces about 260 times as much as an experienced hand embroiderer, as with 234 needles, or 112 in each row, it can make about four million stitches in twelve hours. Lately some machines have been made of double length, or nine meters (29 ft. 6 in.) on the needles instead of 4·5 meters, which would again largely increase the production, but whether these are a practical success remains yet to be seen. The shuttle machine differs from the hand machine previously described in having only one carriage in front of the cloth, with the needles arranged in two rows above each other. These needles are sewing machine needles with eyelets near the point, and at the back of the cloth a corresponding number of shuttles work on tubular carriers, which effect the binding of the needle threads on the back of the cloth. The motion of the carriage is effected by eccentrics keyed upon a longitudinal shaft and acting on the pins of the carriage rollers or wheels. The shuttles are moved by two eccentrics and lever connections, and an arrangement is applied for putting either the one or the other eccentric into gear according as a long flat stitch or a back stitch is to be produced, these two stitches requiring a different motion of the shuttle. While the hand machine is, as its name indicates, worked by hand, the shuttle machine is driven by power, one horse power, however, being sufficient for driving eight machines. This and the way in which the threads are bound on the cloth, and the greater speed, constitute the chief differences in the two kinds of embroidering machines. The shuttle machine is in fact a multiple sewing machine, with arrangements for determining the length and direction of the stitch in place of the feed motion.

Some of the details introduced by the Saechsische Stickmaschinenfabrik deserve a further notice. The needle threads are taken from the bobbins round a loose rough roller, and thence through a thread guide to the eyelets. In proportion as the thread is used up the roller is turned by the threads, by means of which an equal consumption and a uniform tension of all the threads is obtained. Another advantage is that by means of a brake on the roller more or less friction can be put on, and thereby more or less tension given to the threads, and that it can by means of a ratchet wheel on the roller be periodically quite arrested. The thread guide mentioned above serves to pull the thread, which is drawn to the back of the cloth by the shuttle passing through the loop, to the front again after each stitch, and to draw it tight before a new stitch is made, differing in this from the ordinary sewing machine, which pulls the thread tight by the needle piercing the cloth at the next stitch, such an arrangement being of course unsuitable for thin fabrics like net. To enable the workman to devote his attention exclusively to the pattern design, and thus work more quickly, a change bell is applied, which sounds when the needles are just drawn out of the cloth and the cloth frame has to be shifted by the pantograph. The machines are, if desired, provided with counters for registering the number of stitches, the work being usually piece work, and paid for at a certain rate per 100 stitches.

The other kinds of embroidering machines and improvements made by the makers our space allows us only to indicate shortly. These are: Shuttle machines 6 to 8 meters long on the needles; arrangement for coupling two machines in line, so that one embroiderer suffices to guide them; shuttle machines with one inch gauge, carrying 168 needles instead of 112 in the same length; apparatus for changing the colors on shuttle machines without having to rethread the needles; improvements in the motions by which the speed is increased to 80 stitches and more per minute; application of a convenient boring apparatus to shuttle machines; Martini's patent machines, which are arranged with hooks instead of shuttles, and can be run at 80 to 100 stitches per minute; combined embroidering machines, in which both "hand" and "shuttle" needles are employed, and which are provided with a boring and a buttonholing appraratus, as previously described, and are specially suited for colored embroidery in consequence of the facility with which hand needles can be changed.

While there are probably no hand embroidering machines used in England, shuttle machines have been supplied by the Saechsische Stickmaschinenfabrik to Messrs. Chamberlain's and Messrs. Perry's factories of Nottingham, through their agent, Mr. J. N. Johnson; and we see no reason why this trade should not be introduced more largely into this country, as the wages paid for embroidering form a small item in the cost of the finished material compared with the cost of cloth and thread and the interest on plant, and in some of these respects England has the advantage. We also think that there is a field open to embroidery as a means for the embellishment of furniture and dress fabrics to a much larger extent than it is used at present. The fact that four millions, or with double length machines even eight millions, of stitches can be made in twelve hours, renders it suitable for cheap and wholesale manufacture. It can easily adapt itself to fashion, as the preparations for new patterns are very trifling compared with those required in weaving; the workman has to change merely the pattern design before the pantograph, and the thing is done. Embroidery is not tied to a rectangular crossing of the threads, but can operate in any direction, obtain raised figures, pierce holes and work around them, produce "applique" effects by means of other tissues, while at the same time the length of thread used is only about double that seen on the face of the cloth, and with shuttle machines, a cheap back thread can be combined with a more expensive face thread. All these are important advantages compared with weaving, in which the preparations for new patterns of a varied kind require a considerable outlay; while for multicolored designs the proportion of the total length of thread to that showing on the face is often very large. The number of colors in weaving is also limited to a greater extent than in embroidery, and on the whole we should think that embroidered fabrics would have a good sale and future. In length the design is limited by the gauge of the needles, which is usually 1½ in.; but by omitting needles, patterns 3 in., 4½ in., or 6 in. length can be produced, while the depth is practically unlimited. By combining pattern weaving with embroidery, especially rich and artistic effects could be produced, such as we at present generally only find in Oriental goods preserved in the museums of art schools, but which the cheapness of machine embroidery might render accessible even to slender purses.—*Textile Manufacturer.*

APPLICATIONS OF FLAME TO HEATING PURPOSES.

By Prof. OLIVER J. LODGE, D.Sc.

THERE is little doubt but that the experience of many engineers and manufacturers is hostile to the complete combustion of fuel—technically called the consumption of smoke—regarded from the point of view of economy. In boiler fires it is continually found that as smoke is consumed, so is the output of steam decreased; and, so long as this is the case, it is hopeless to expect the non-emission of smoke from boiler fires, except under very severe penalties, which the community would be loth to exact. In high temperature furnaces, experience of smoke consumption is far less discouraging, and there are not wanting manufacturers to assert, on apparently good grounds, that they effect some 40 or 50 per cent. economy in coal now that they adopt a more perfect system of firing.

At first sight, economy of fuel would appear to be a necessary result of an enlightened design of furnace and of perfect combustion; and if in certain cases this result does not follow, but rather the contrary, there must be a reason, which it behooves one to discover. In the light of the researches of Mr. Frederick Siemens, the views of Professor Armstrong, and some recent experiments by Mr. Fletcher, the reason is not far to seek.

The first and obvious ideas on the subject were somewhat as follows: Smoke combustion has been attained by the admission of an extra supply of air at a certain point of the flame, so that none of the gas formed may distill over unburnt, but that all may meet with a due supply of fresh air, unsophisticated by passage through red-hot coke, and thereby deprived of its active element. It is plainly desirable to admit no more air than is necessary, especially when one considers that every cubic foot of oxygen brings with it four or five cubic feet of inert nitrogen, which has to be raised to flame temperature, and which acts simply as a cold diluent. Hence attempts are often made to proportion the supply of air to the supply of fuel, and to allow for the rapid evolution of gas which goes on directly fresh coal is injected. This can be done in two main ways—first, by making the extra air supply intermittent in quantity, to suit the intermittences of stoking, extra air being admitted every time a fresh shovelful is thrown in, and for some time afterward, as in Prideaux furnace doors; secondly, by letting the air supply be steady, but making the fuel supply steady also, as with automatic stokers. It is also plainly desirable to supply this fresh air not cold, but hot; and the waste heat of the furnace is, in the best arrangements, utilized to effect this.

This being all well known, I say the first and obvious idea as to the cause of the diminution of steam supply, when a smoke-consuming arrangement is introduced, is that either too much air has been introduced, or that it has been introduced cold. Either of these causes will certainly assist to produce the effect; but, considering that, however carefully they be avoided, no great economy of fuel results—at least in boilers—and considering that, unless air is so introduced, immense quantities of gas and combustible matter escape unconsumed, it is pretty plain that the cause of the paradoxical wastefulness of perfect combustion must be another and more deep seated.

Consider, therefore, the two classes of flame; one in which combustion is imperfect, the other where it is thorough and complete—for example, say a paraffin lamp without a chimney, and the Bunsen lamp of a laboratory. The one is luminous and smoky, its radiating or toast-making power, is great but it is unable to heat bodies put into it much, because it coats them so thickly with soot. The other is clear and non-luminous, its radiating power is extremely small, but it is supposed to heat bodies put into it very well; certainly it does so better than the other. But does it, after all, heat bodies put into it so perfectly? The answer, after consideration, must be: If they are such as can become white hot, yes; if they are such as remain comparatively cool, no.

A piece of thin wire, or ash, or dust, is well and perfectly heated; a cold soldering or flat iron, or a kettle, is slowly and very imperfectly heated. And why? For two reasons—first, because it interferes with combustion. For combustion, a certain temperature is necessary. Heat mixed oxygen and hydrogen to any temperature short of this, and they hardly combine at all; if they do, it must be a very slow process. Heat them up to the right temperature, and they burn at once. Now, a kettle of water introduced into a flame instantly cools a great part of it below the igniting point, and the gas burns in a very imperfect manner, as is evidenced by the irritating smell of acetylene. That is one reason, but that is not the whole; perhaps it is not the main reason. The second reason is, that *the flame never really touches the body it has to heat.* How can it? The body is at nothing like the temperature of flame, and accordingly no flame can exist in contact with it. Combustion is not only imperfect, it actually ceases within a short distance of the surface. A layer of dark, non-conducting air or gas, at some quite moderate temperature, intervenes belween flame and kettle; and across this film, heat can only pass by radiation. No non-conductor is so perfect as air or gases. In so far as the film is warm, it may indeed impart some heat to the surface, but little; the great part of the heat has to be transmitted through the film by radiation from the main body of the flame.

But then this non-luminous flame is a shockingly bad radiator, and so very little heat really reaches the surface at all. What, then, is the remedy? There are two. Either the surface to be heated must be allowed to get red or white hot, and so permit the actual contact of flame without interfering with combustion, and without interposing a non-conducting, dark, gaseous layer; or else non-luminous flames must be abolished, and highly radiating ones used instead. The former is Mr. Fletcher's plan, the second is Mr. Frederick Siemens'.

If the bottom of a copper kettle, instead of being $\frac{1}{16}$ in. thick, is say 3 in., or perhaps more, there is some chance that the outer skin of it may be raised to a

white heat by a perfect "solid flame" burner placed underneath it. In this case, combustion will not be interfered with, and a torrent of heat will pass through the copper into the water, the gradient being some 1,000 or more degrees per 3 in. Thus we arrive at the paradox that a thick bottomed kettle may boil water quicker than a thin one. This is not, indeed, Mr. Fetcher's way of putting the matter, nor is it his plan. He proposes a multitude of studs, or ribs, to project from the bottom of the kettle, or inside of the fire box, into the flame, to receive its heat without unduly chilling it. It seems to me that the thick slab is simpler, and likely to be more effective.

The other plan, that of Siemens', is to avoid flame contact altogether, to use a highly luminous and regenerated flame, and to work solely by radiation. This seems to me the better plan on the whole, especially as it avoids burning of surfaces.

Admitting that flame cannot really touch the ordinary surfaces which it has to heat, don't try to make it touch. Admitting that the heat of a flame must reach such surfaces ultimately by radiation, increase the radiating power of your flames as much as you can, so as to get the greatest possible advantage from them. This is probably the future method of applying combustion heat in all industries—rich gas supplied with intensely hot air, and burning at an excessively high temperature in free space.

Returning now to the consideration of ordinary smoke consumers, the reason of their lack of economy is, I think, manifest. Without such arrangements the flame is smoky indeed, but luminous; it contains plenty of solid matter, and, therefore, has considerable radiating power. Its temperature is, indeed, not very high, nor is the combustion at all perfect; but still, as it passes along the flue, it can send out a lot of heat to the surfaces; and even when the flame has ceased, the hot carbon particles continue their journey, and radiate as they go.

But admit sufficient air supply to render the combustion perfect, and note the change. A non-luminous or only partially luminous flame, almost free from solid matter, now passes along the flues, and radiates to them very little. True, cross tubes are inserted for it to play against; but, as we have seen, it cannot really touch them, it must do its heating ultimately by radiation, and it accordingly is unable to accomplish very much. It is not, indeed, necessary, or advisable, or customary in practice to admit air enough to render the flame really blue and non-luminous. I have only put an extreme case.

We may sum up the two cases thus: With smoke: Great escape of unburnt matter, both gaseous and solid, and low temperature flame, but good radiating power and large percentage of heat really given to the boiler. Without smoke: More or less complete combustion and hotter flame, but poor radiating power, and smaller percentage of heat produced really utilized; though, as more heat is produced in this case than in the former, the actual heat utilized may be much the same in both. With some arrangements one plan gives an advantage; with others, the other.

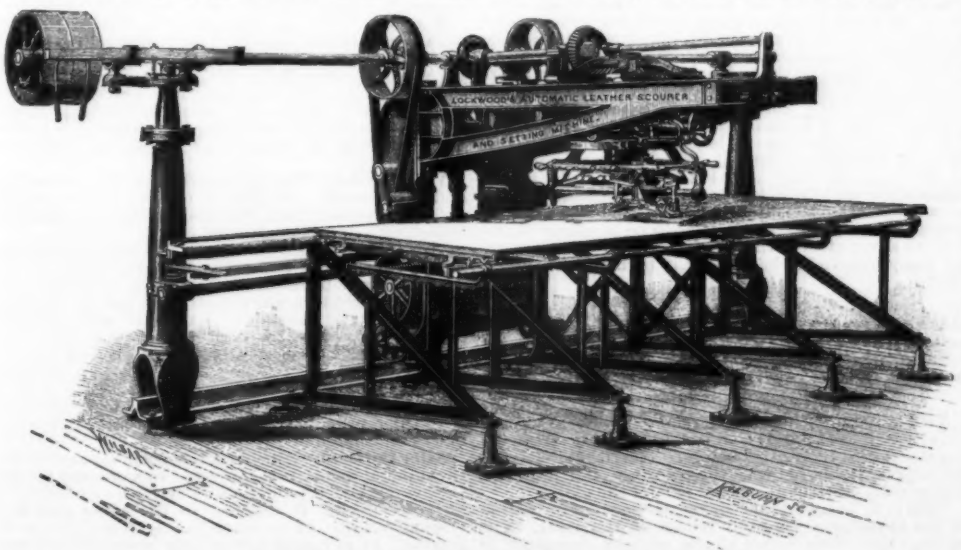
Evidently, to high temperature furnaces, where no cold surface need come near the flame, these considerations scarcely apply, and complete smokeless combustion can then hardly fail to be much more economical than incomplete; though, indeed, Mr. Siemens thinks that all solid contact interferes with a flame—inducing dissociation—and he accordingly endeavors to keep flames from contact even with white hot surfaces, and to work solely by radiation.

This seems to me the direction to look for perfection. To increase the temperature of a flame by regeneration; to increase its burning or radiating power by a sufficient supply of solid matter; to keep it out of contact with a solid surface, making it play down the center of flues, or causing it to form a sheet under and round a kettle; and to adjust the air supply so that combustion is quite perfect, and no unburnt or semi-burnt gas or solid matter escapes to cause noxious smells, and to foul the atmosphere.—*Industries.*

LEATHER DRESSING MACHINE.

ALTHOUGH the currying industry is one of great antiquity, an automatic leather dressing machine is in itself somewhat of a novelty. Apart from the interest in this respect attaching to Lockwood's automatic leather scourer and setting machine, shown in the machinery section of the Edinburgh Exhibition, and illustrated by our engraving below, the exhibit has claims upon our notice for other reasons. The ingenuity of design and accuracy of workmanship are fully evidenced in the ease, regularity, and precision with which it performs the variety of motions required. The machine, made by Arrol Brothers, of Germiston Ironworks, Glasgow, is an American invention. Frederic A. Lockwood, of Boston, Mass., is the inventor. While it is a comparative novelty in England, scarcely a dozen being at work, it is universally coming into use in the States, where, from extended experience of its labor-saving capabilities and the quality of its work, it has come to be regarded as a necessary to the currying industry. With two men in attendance, it is claimed that the machine can do as much work as seven men can do by hand, while the quality of the work is superior. The machine combines movable tools working in any direction required over a fixed oblong table of solid slate, which can at any time be quickly leveled up and adjusted by means of a series of set pins. The whole of the mechanism behind the table, which we may call the truck, together with the crane arms or brackets overhanging the table—which are rigidly attached to a fixed part of the truck—travels automatically in either direction along the length of the table, driven by a nut which bears against the truck and rotates on the screw shaft seen behind the table. This nut is rotated by reversible gear driven off the small pulley on the left side of the truck. That part of the mechanism inside of the crane arms which we may speak of as the carriage is automatically moved transversely in relation to the table by means of a screw-threaded shaft, the screw fitting a nut fixed to the rear part of the carriage. This screw shaft is rotated by an ingenious combination of bevel gearing and shafting, driven in their turn off reversible gear and pulley on the right side of the truck, similar to those on the left side controlling the travel of the truck longitudinally. Both of these principal motions—*i. e.*, the travel of the truck longitudinally and of the carriage transversely, relatively to the table—are by an interlocking controlled by one and the same guide lever, a small handle which may be seen hanging down in front of the carriage. The so-called "carriage" is in three distinct parts—the trundle frame, the head, and the yoke. The trundle frame is only capable of moving backward and forward transversely to the fixed table inside of the crane arms, bearing with it the head and yoke. The head is vertically adjustable with relation to the horizontally movable trundle frame, and is raised or lowered by turning the small hand wheel seen directly in front of the carriage, thus bringing the reciprocating tools nearer to or further from the table, giving pressures heavy or light as required, while the machine is in active operation. Below the head is mounted the yoke, carrying the guide rod, which receives the reciprocating tool carrier, which yoke is movable axially as regards the head and trundle frame. When it is desired to repeat the strokes in the same direction several times, the inventor has provided a latch capable of locking the yoke rigidly to the head, and preventing its revolving. The actual horizontal stroke is converted from the circular motion of the upright carriage shaft by a crank carrying a spur pinion which gears into an internal spur wheel situated in the yoke above the guide rod of the reciprocating tools. This upright carriage shaft is driven at the speed of 120 revolutions per minute, off the bevel gearing above the carriage on the so-called top-shaft, which top-shaft is, in its turn, driven off the miter gearing on the main driving shaft above the truck at the speed of 240 revolutions per minute.

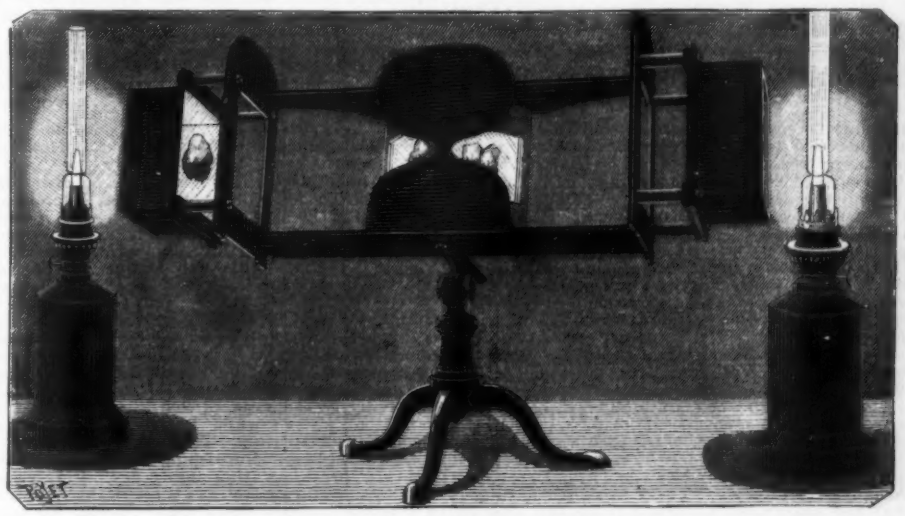
The machine works with either or both tools, which can be at once raised or dropped, and when working one tool is always in the table while the other is off, the two tools setting in opposite directions. The tools have a lifting motion imparted to them by the upper side of the tool carrier frame resting against the under side of rotating cam fixed to crank. The table, which is 22 ft. long by 5 ft. wide, is large enough to accommodate two or more pieces of leather simultaneously, in such a manner that one man can be preparing a hide at one end while the other man is directing the machine in the automatic setting out of a hide previously arranged at the other end. The working thus keeps two men constantly employed, but the physical labor is light, for the machine takes the brunt of this. Extra weight and extra size of leather are, it is said, obtained by the machine, as compared with hand work. Six are at work in Glasgow—three at Messrs. John Tullis and Son, engaged on strapping, and three at Messrs. Hamilton, Caldwell, and Sons on the lighter work connected with shoe leathers.



IMPROVED LEATHER DRESSING MACHINE.

PHOTOGRAPHS EXHIBITING EXACT PERSPECTIVE.

ABOUT a year ago, Prof. Marey made known to the French Society of Physics the result of his experiments performed for the purpose of expressing by stereoscopic photography the trajectory of a point that is moving according to the three dimensions of space, a problem that presents a certain interest for the study of the gait of man and flight of birds.



CAZES' STEREOSCOPIC APPARATUS.

On taking two simultaneous photographs of the movement of a brilliant point with a stereoscopic apparatus, we obtain images that give the sensation of a well characterized relief. The trajectory assumes the appearance of a brilliant thread, bent in various directions, and the inflections of which vary with the nature of the gait. This has led to a discussion between Messrs. Marey, Napoli, Cornu, and Javal on the subject of the distances apart to place the objectives of the two photographic apparatus, in order to obtain the best conditions of stereoscopic restoration.

This is a problem that Mr. Cazes has endeavored to solve by putting it thus: What are the conditions to be fulfilled in order that two photographs of an object, A, shall give, through a simultaneous observation in the stereoscope, the same sensation as that which would be produced by a real object, A′, like the first, but of different dimensions and placed at the distance of distinct vision?

When the eyes move in succession from one of the nearest points of the object, A′, to one of the most distant, the visual angle and the accommodation change at the same time. When, on the contrary, we contemplate the two images at a fixed distance, the visual angle alone must change in order to superpose the various corresponding points, while the accommodation remains the same. Projections in the stereoscope cannot replace the object unless the latter has a maximum depth such that the eye, accommodated for the nearest point, still clearly sees the most distant one.

For a normal vision, v, of 30 centimeters (1·18 in.) such depth is about 3 centimeters (0·118 in.). It increases or diminishes with v, and we can, without sensible error, take it as equal to $\frac{v}{10}$.

In order to obtain two photographs of the object, A, identical with the two considered projections of A′, the cameras must form with a point of the object, A, an angle equal to the visual one when we are looking at a point at the distance, v, say from 12° to 15°.

Let D be the mean distance of the object, A, from each of the objectives; f, the distance from the optical center of the objective to the image of the object, A, furnished in the camera; and d, the depth of the object, A, that is to say, the distance of the two extreme planes limiting the object, and at right angles with the bisectrix of the cameras.

The minimum distance of the object from the objectives will be determined by the relation

$$D = \frac{10}{v} f d.$$

The maximum of D is limited only by the small size of the negatives obtained.

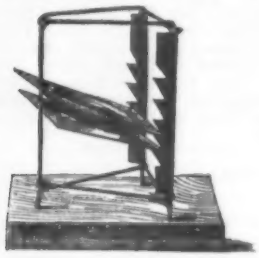
By observing these conditions, Mr. Cazes has obtained some very interesting photographs of crystals, giving the sensation of accurate perspective, upon being examined in the stereoscope represented herewith.

The positives (upon glass) are illuminated by transmitted light, and are reflected from two mirrors at an angle of 45°, which send the images in the line of direct vision.

A comparison of stereoscopic and original views brings into relief (the word is here doubly exact) the accuracy of the principles pointed out by Mr. Cazes for obtaining photographs showing exact perspective.—*La Nature.*

PHOTO PLATE RACK.

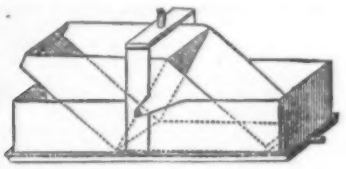
ASHMAN'S rack for plates is represented by the accompanying sketch. It is made of wire and sheet metal, and when not in use can be folded so as to lie



flat. By its use a number of plates can be readily lifted from the wash water, and put into a fresh supply.—*Photo. News.*

AUTOMATIC APPARATUS FOR WASHING NEGATIVES.

THE annexed engraving represents an automatic apparatus devised by Mr. Gorceix for washing photographic negatives. It consists of two triangular prismatic troughs placed back to back, and oscillating on a rod passing through them a little above their center of gravity, and supported by two uprights. The oscillation causes the partition common to the two troughs to take two positions, one to the right and the other to the left, that make an angle of about 15° with the vertical. The uprights are fixed to the sides of a box provided with a waste tube, and are connected at their upper part by a cross-piece, that carries a tube through which water continuously enters the troughs. The water on entering the compartment below raises the center of gravity laterally, and when the latter gets above the axis, the troughs tilt. A part of the water is thus emptied into the box, while the rest, being held back by a narrow rim, covers the plate and enters the gelatine. As a consequence of the rocking motion, the other trough is brought under the stream of water, and becomes full in its turn, and the two troughs then tilt in the opposite direction. These motions continue as long as the water flows, and their frequency depends upon the discharge, which may be regulated at will by means of a cock. It will be seen that when once operations have begun, the washing proceeds very regularly. The negative soaks for a certain length of time in the water, and gives up to it a portion of the salts that it contains, and then a larger bulk of water dilutes the solution and is in part ejected, so that the strength of the liquid lowers so rapidly that there are soon only inappreciable traces of solids in the water, and the washing is then finished. When it is a question of rid-



ding paper proofs of hyposulphite of soda, the troughs are covered with wire cloth with wide meshes, which holds the proofs without interfering with the circulation of the water. The apparatus is made of zinc covered with bitumen, which is afterward exposed to the sun.—*La Nature.*

PRINTING WITH ARISTO-PAPER.

By W. E. WOODBURY.

ARISTO-PAPER is a name given to a new gelatino-citro-chloride paper, manufactured by the firm of Ed. Liesegang, in Dusseldorf, Germany. The use of this paper is so rapidly spreading that a few words upon the necessary manipulations will, I am sure, not be deemed unnecessary. This paper is sent from the factory ready sensitized, and keeps good from two to three months if kept in a dry place; its surface is very fine, and a little care must be taken in handling it; in fact, touching the sensitized surface must be avoided as much as possible.

The paper, having been cut to the required size, must be placed in the printing frame, thoroughly dry, in the same manner as the ordinary albumen paper: the printing to be carried only to the depth required when finished. The print will be of a purplish, the dark parts being of a slightly bronze color. This paper will be found to print at least three times as quickly as the ordinary albumen paper. In washing the prints, they must be placed face downward, one by one. The water must be changed five or six times, until there is no appearance of milkiness. The first washing may be continued from three to five minutes, and the water preserved, as, in consequence of a much larger amount of silver required in the manufacture of this paper than in albumen, a large quantity comes out in the washing. It is placed in a tub, and the silver precipitated with common salt each evening, the clear water being decanted and thrown away the next day. The importance of preserving the water may be estimated when it is stated that from one sheet of the aristo-paper, 19 by 23 inches, cut into eighteen cabinets, 23 grains of chloride of silver were obtained by washing.

The prints having been thoroughly washed, they are ready for the toning bath. One of the most reliable and satisfactory for this paper is the following bath, composed of two solutions:

(*a*)	Water	3 ounces.
	Chloride of gold	2 grains.
(*b*)	Water	3 ounces.
	Sulphocyanide of ammonium	40 grains.
	Hyposulphite of soda	1 grain.
	Carbonate of soda	3 grains.

Mixed together by one part of *a* being poured into an equal part of *b*; in no case the reverse.

A little care must be taken in placing the prints in the bath. With the *right* hand take the prints from the washing dish, and submerge them, one by one, in the toning solution. Each print must be thoroughly and evenly wetted, and kept in motion, or unequal toning will be the result. A large number of prints should not be toned at the same time, as care must be bestowed upon each print. On immersion in the gold bath, the prints will be observed to turn quite yellow, and then into a brown, and afterward into a purplish-brown tone. As soon as the last-mentioned color is arrived at, they should be taken out, and placed at once by the *left* hand (which must on no account come into contact with the other baths) into the fixing bath without washing. If the toning bath contains too much gold, the prints will not become yellow, but immediately blue; more water should then be added. The same bath can be used over again, but the operator must, in this, use his own discretion. Of course, if a large number of prints have been toned, and the bath appears to be weak, it is advisable to change. The acetate of soda bath can also be used with satisfactory results.

The Fixing Bath.

Hyposulphite of soda	10 ounces.
Water	100 ounces.

Should be kept as far apart as possible from the other baths, and the prints taken from the toning bath with the right hand, delivered into the left, and with the left hand placed in the fixing bath. From five to ten minutes is generally sufficient, but by holding the prints up to the light it can be easily seen if they are thoroughly fixed. A mottled dirty yellow appearance indicates insufficient fixing. The prints must now be washed in the most thorough manner for one or two hours, although the time is of secondary importance to the perfectness of the changes. Having been thoroughly washed, they are taken out and dried by laying across a long pole or similar arrangement, but on no account placed between blotting-paper. Cutting and mounting should be done in the ordinary manner, the most suitable mounting solution being made by dissolving two ounces of hard gelatine in twenty ounces of water; while hot, pour in one ounce of alcohol, well stirring. This is applied while warm with a stiff brush. Burnishing must not be done before the prints are thoroughly dry. Lubricate with Castile soap and alcohol, run through the machine from a different corner every time, slowly, the machine being not too hot. Should, however, a highly glossy surface, equaling glass in appearance, be desired, the following is the method of obtaining it: Some glass plates large enough to hold half a dozen cabinets on either side, some powdered talc, cotton-wool, a good supply of blotting-paper, and an India-rubber squeegee are required. Lay a sheet or two of the paper upon the table, and upon it place the glass plate, thoroughly clean, then dip a small pad of the cotton-wool into the talc, and rub the glass well all over with it. Now with a fresh piece of wool dust till none of the powder is visible, although every pore in the glass is filled with minute particles. The prints being thoroughly washed, take them out of the water one by one, and lay directly upon the glass plate; having filled the one side, place a sheet or two of blotting-paper over the whole, and press well. Now remove the paper, and go over each print separately with the squeegee, removing all the air from between the surface and the glass, and again take up all the superfluous water with the blotting-paper. Now turn the plate over, and repeat the operation upon the other side.

When thoroughly dry, by placing a knife under one of the corners the print will peel off with the desired surface. By the same process, but by employing a matte or ground-glass, a matte surface equal to platinotype can be obtained.

This may seem to the reader to be a long and troublesome process, but in practice it is not. One hundred prints an hour can be put on glass plates with the greatest facility. The advantages of this paper over albumenized paper can be summed up as follows: The prints are infinitely superior, and reproduce to perfection all the details of the negative. From weak negatives, that do not give good prints on albumenized paper, very good prints can be obtained, because the light parts become lighter, and the dark ones darker and more vigorous, there being a much greater range of gradation. The printing is from two to three times more rapid. Any surface can be obtained, from the highest polish of an enameled print to the matte surface of an engraving. A larger quantity of silver is saved in the washing waters. The prints do not fade in the same manner as albumenized prints, as the organic salt employed is a definite compound, and not so uncertain as the albuminate of silver is. In this paper citrate of potassium seems to be in excess, therefore no silver attacks the gelatine, and the prints are by many believed to be absolutely permanent.—*Photo. News.*

CARBONIC ACID GAS IN MINERAL SPRINGS, AND ITS PRESENT UTILIZATION AS AN ARTICLE OF COMMERCE.

By N. T. REDLICH.

THE mineral springs of Germany, which are particularly rich in carbonic acid gas, have lately attracted greater notice than ever before. The Rhine districts are especially blessed with these springs, and possess a larger number than any other part of the globe.

This is to be accounted for by the peculiar formation of the mountains on both banks of the river. The springs have their source almost without exception in valleys between the several mountain ranges. The mineral water forced from the heart of the mountains is prevented from finding an outlet, in a great measure, by deeply embedded masses of debris, and the origin of springs is only permitted in deeper valleys, where such masses are carried away by the water. At the points where the rock is nearly bare or less obstructed, the mineral water can penetrate and appear in the form of springs.

The gas which is ceaselessly rising from the waters in the form of bubbles, in immeasurable quantities, is carbonic acid gas. As soon as it has left the water it is no longer visible; but, owing to its weight surpassing that of the atmospheric air, it remains on the surface, flows slowly away, and becomes gradually diffused in the surrounding atmosphere.

The carbonic acid gas rising in the form of bubbles is completely dissolved at greater depths. Water has the capacity—under the usual atmospheric pressure and at a temperature of 32° Fahrenheit—of absorbing its own volume of carbonic acid gas, so that a bottle filled with this gas can be filled with water, without any of the gas being forced out. Under a lower pressure and at a higher temperature the water absorbs less; at a higher pressure, however, a greater quantity.

A pressure of two atmospheres, or 30 pounds to the square inch, is found in the water itself, at a depth of 32 feet, and at a greater depth a proportional increase of pressure is observed. There is no doubt that there exists in the heart of the mountains quantites of very highly compressed carbonic acid gas, which are absorbed by the water wherever they come together.

The difference in the affinity of carbonic and silicic acids is the cause of the great circulation in the interior of the earth. One acid must give way to the other, according to the corresponding proportion of pressure and heat. On the surface of the earth, where such a pressure and temperatnre prevail that vegetable and animal life are possible, carbonic acid possesses a stronger affinity for alkali, earthy bases and metallic protoxide, than the silicic acid. In those strata of the soil near the surface, the carbonic acid decomposes the minerals of which silicic acid is one of the component parts. With the increase of temperature such affinity decreases and ultimately disappears, so that in the deeper recesses of the earth, where higher temperature prevails, the silicic acid becomes predominant and the carbonic acid is expelled wherever it forms a component part of minerals, the silicic acid taking its place. In the bosom of the earth, carbonates become silicates. The entire operation is effected through the mediation of water and its affinity for the bases on the one hand and for carbonic acid on the other.

The strata of the Rhenish mountains consisted at the time of their formation of layers of more or less pure carbonate of lime. Those masses now forming the summit of the mountains, and those immediately beneath the surface, were embedded in much deeper regions, when the mountains stood at their original altitude. That they must have formerly been considerably higher is shown by the interior formation of their foundations. Those minerals of which carbonic acid formed a component were in consequence of being so located (as before described) converted into silicates. This was effected by the silicic acid which had become liberated in the upper regions. The same process of circulation which caused the constitution of the now upper strata gradually moves into deeper regions, in the same degree as the mountains become lower by the erosive action of water. At present this takes place in the greater depths of the foundations, where the rocks have not yet lost their original constitution and riches in carbonates. The carbonic acid, which in such depths is released from chemical combination by the superior affinity of the silicic acid, joins itself to the water and streams with it to the surface. It is driven upward with great force by its own power of expansion or by the pressure of the water. Sometimes the carbonic acid rises upward in gaseous state from the heart of the mountain until it reaches strata richly impregnated with water. Here it becomes absorbed by the water in quantities which are in proportion to the pressure in those regions.

Such is the manner in which mineral waters rich in carbonic acid gas originated; those proceeding from great depths are known as hot springs, and those from the upper strata as mild and cooling.

The springs on the Rhine are mostly mild, cooling, and acidulous. The water does not rise from those depths in which the transformation from carbonates to silicates takes place, as is proved by its relative temperature. The carbonic acid, however, streams from such an interior chemical laboratory, and is absorbed by the cooler water at a moderate depth only, from whence it is forced upward by the expansive power of the gas.

Scientists have often visited the springs, and have found that the carbonic acid gas is not only in immeasurable quantities, but also chemically pure.

Many endeavors had been made to separate the gas from the mineral water. These efforts, however, all proved ineffectual until quite recently. After several years' experiments Mr. O. Brunler succeeded in finding a process by which the carbonic acid gas can be separated from the water. It is said that his process is a physical one and very simple, and that it is possible by his method to obtain enough gas to supply the whole world.

This discovery attracted much attention in scientific and other circles. Sufficient capital was subscribed, and the necessary buildings and machinery erected for collecting and condensing the gas.

This is done at present in two different places. The first establishment was erected at Honingen, a little village near Coblenz on the Rhine. It was soon found that the machinery was not large enough to meet the requirements of the trade. Extensive additions were made to the works at Honingen, and at the same time new buildings on a larger scale were erected at Obermendig, in the Eifel mountains. The two establishments are controlled and the business is conducted by the International Institute for Liquefied Carbonic Gas, with their principal office in Rotterdam, and branch offices in London and New York.

After the carbonic acid gas has been separated from the mineral water, it is subjected to a gradual pressure—by compression pumps, especially constructed for the purpose—until it is reduced to the 450th part of its original volume, at the same time undergoing a cooling process. It is forced into strong wrought-iron cylinders.

At a pressure of 52 atmospheres, or 780 pounds to the

square inch, and at a temperature of 59° Fahrenheit, the gas turns into a colorless liquid resembling water. It returns, however, to the gaseous state as soon as the pressure is removed. As the result of such compression, we have a large volume of gas stored in the smallest possible space; while the pressure expended in liquefying the gas may be regained on its expansion, and an intense cold may be produced by permitting the gas to return to its natural gaseous condition.

Such an iron cylinder represents therefore a reservoir not only of gas, but also of pressure and cold.

Its liquid condition has the decided advantage that a large quantity of gas can be contained in a small vessel, and be applied by opening a valve with discretionary pressure.

The cylinders are made of wrought iron, 4 feet high and 5½ inches in diameter. The walls are ¾ of an inch thick. The valve attached to the cylinder is made of brass and steel. The weight of the empty cylinder is 88 lb., and of the liquid 22 lb.

Although the pressure exerted by liquid carbonic acid amounts at 32° Fahrenheit to 36 atmospheres, or 540 pounds per square inch, and rises at 59° to 52 atmospheres, or 780 pounds, and at 86° to 73 atmospheres or 1,095 pounds, every danger is excluded, as the vessels are most carefully made, and are submitted annually by the government officials to a test pressure of 250 atmospheres, equal to 3,750 lb. to the square inch. Even an external damage to the cylinder or the valve would only cause the gas to stream out with a loud hissing noise, without any explosive result whatever.

The object which the Institute has in view is not only to introduce this natural gas in its liquid form for general purposes, but also to revolutionize and effect a thorough reform in the present incomplete methods of manufacturing carbonated beverages. For this purpose carbonic acid gas taken from the springs, on account of its never varying purity, is of great value. The public prejudice against carbonated beverages is partly excusable, but only in regard to their manufacture. Ignorance on the part of the manufacturer, together with insufficient apparatus, are the reasons that so many unwholesome beverages are sold. The principal cause, however, lies in the production and purification of the carbonic acid gas. Generally, this gas is produced by dissolving marble dust in vitriol, and is then conducted into so-called "purifiers," and washed. The gas produced in this manner contains poisonous ingredients, although there is no doubt that with sufficient knowledge and proper care it could be produced chemically pure. Experience, however, teaches that this rarely occurs; and even in such factories where special care is taken and no money spared for good and efficient apparatus, mistakes and negligence are still unavoidable.

The methods hitherto adopted in the artificial production of carbonic acid gas do not hold out to the public that guarantee which it demands; but the consumer had always to rely implicity upon the skill and care of the workmen employed.

By the use of liquid carbonic acid, the manufacture of aerated beverages is considerably simplified; the laborious, unclean, and unpleasant work of generating the gas is avoided; apparatus, manual labor, and time saved.

By the contents of one cylinder—22 lb. of liquid carbonic acid—220 gallons of soda, mineral waters, etc., can be produced, which is well charged at the usual pressure of 60 lb. per square inch. As one lb. of liquid carbonic acid gas is sold in the United States for thirty cents, soda water, etc., can be produced at a cost of three cents per gallon.

For breweries this gas, in its liquid form, has become a necessity. Up to the present time the method of impregnating beer with carbonic acid, with the aid of bicarbonate of soda, was widely practiced; its decomposition through the agency of acids, generating the necessary carbonic acid to produce the desired pressure in the beer. By the use of liquid carbonic acid, all necessity for the use of bicarbonate of soda is obviated. Another valuable utilization in breweries consists in the property of compressed carbonic acid gas for clearing clouded beer in the shortest possible period; whereby the brewer is enabled to replace three-fourths of the finings formerly used by a cheap and more rational process.

The headquarters of the International Institute for this liquefied carbonic gas are at 857, Broadway, New York.

A NEW SAFETY CARTRIDGE FOR COAL MINES.

A NEW safety cartridge for use in mines where it is not safe to blast with gunpowder has lately been introduced in Germany by Dr. Kosmann, of Breslau. Its action depends upon the rapid liberation, in the borehole, of a large quantity of hydrogen gas, the pressure resulting from which forces the coal or rock asunder. The hydrogen is liberated by means of the action of sulphuric acid upon very finely divided metallic zinc. For this purpose Dr. Kosmann takes the bluish-gray powder which forms in the condensers of zinc distillation furnaces, and which consists of metallic zinc which has not been condensed to the liquid form, but results as a powder, or as a more or less spongy mass. There is a small amount of oxide mixed with it, but for all practical purposes it may be considered as metallic zinc. The cartridge consists of a glass cylinder, narrowing to a neck, and being also contracted at a point below the neck, so that the cylinder is divided into two portions, communicating through a contraction whose opening is 8 mm. to 10 mm. The contraction is so placed that the two parts of the cylinder are to one another in cubic capacity as 1 to 4, the smaller part being near the neck of the cylinder. The lower or larger division is filled with sulphuric acid obtained by diluting the chamber acid of commerce with an equal volume of water. The contraction is then closed with a stopper of rubber or cork, and in this condition the cylinder is handed over to the miner. The hole, being bored ready in the coal or rock, is well clayed over inside, in order to close any cracks or cavities through which gas could escape. The upper part of the glass cylinder is now charged with the zinc powder, and an iron rod is laid in, passing through the zinc, and resting upon the stopper in the contracted part of the cylinder. The neck of the cylinder is then tightly plugged with clay, and it is laid in the hole, which is then also well tamped with clay, the iron rod passing through both these clay stoppings, and projecting some little distance beyond. In order to "fire the shot," the miner strikes the iron rod with a hammer, so as to drive in the stopper in the contracted part of the cylinder, or to break the glass at that part. In either case the acid at once runs in among the zinc powder, and a very rapid evolution of hydrogen takes place. The iron rod is not uniform in thickness, but conical, being thicker toward the outside, and this increase of thickness is considerable, so that when the rod is driven in, it keeps tight in the clay stoppings, and prevents any escape of gas. The inventor gives figures to show that a cartridge 180 mm. long and 25 mm. in diameter, taking a charge of 50 cubic centimeters of acid and 12 grammes of the zinc powder, will give rise to an evolution of gas equal to 2·37 cubic meters at ordinary barometric pressure; and that the compressure of this volume of gas into a space of 90 cubic centimeters means a pressure exerted on the sides of the hole equal to some 37,000 atmospheres. The pressure is obtained rapidly, but not so rapidly as to in any way endanger the man who drives in the rod. He has plenty of time to get away before any coal or rock comes down. It does not appear that these cartridges have yet had any thorough trial in practice, but much is expected of them, and the making of the cylinders has been intrusted to a large firm who will insure their being good and uniform. The cost of each "shot" will be one penny to three half-pence, according to size of the cylinder and charges used.—*Engineering.*

DRAWING ELLIPSES.

THERE are many ways of drawing ellipses, from the wretched way commonly described as a good way (the string-and-pin method) to very complicated though very exact methods. Perhaps there is no way much simpler than that illustrated in Fig. 1. Two equal series of equidistant circles are described around each focus, and the intersections of the successive circles (taken increasingly) of one set, with the successive circles (taken decreasingly) of the other set, give an ellipse. To determine an ellipse having given foci, and a given minor axis, one has only to take that particular ellipse, of several given by the construction, which passes through the ends of the desired minor axis. (Or the major axis, if we prefer it, may be used to determine the ellipse.) Of course, it is quite easy to take the radii of our circles so that two equal circles around the foci shall intersect at extremities of any indicated minor axis, or, if we prefer it, two circles around the foci may intersect at any desired distance from either focus to determine an end of the major axis; after that taking equal divisions along the major axis, produced if necessary, we get all other radii. Fig. 2 illustrates a similar method for drawing any desired hyperbola. —*Knowledge.*

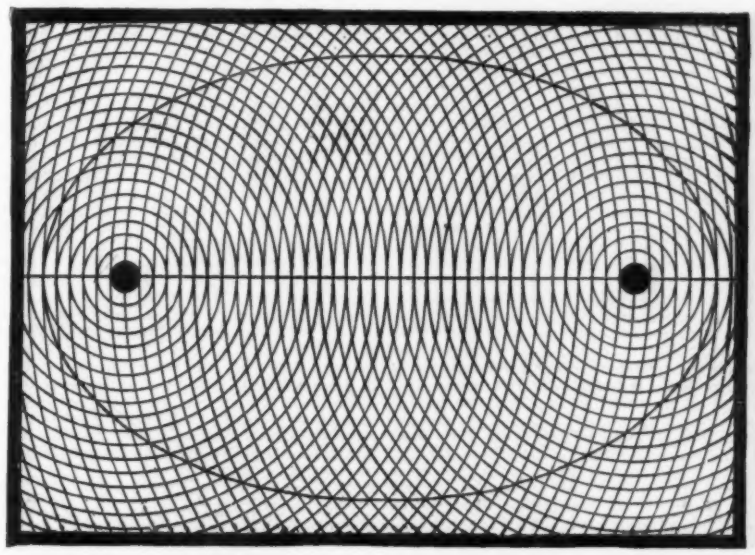


FIG. 1.—DRAWING ELLIPSES.

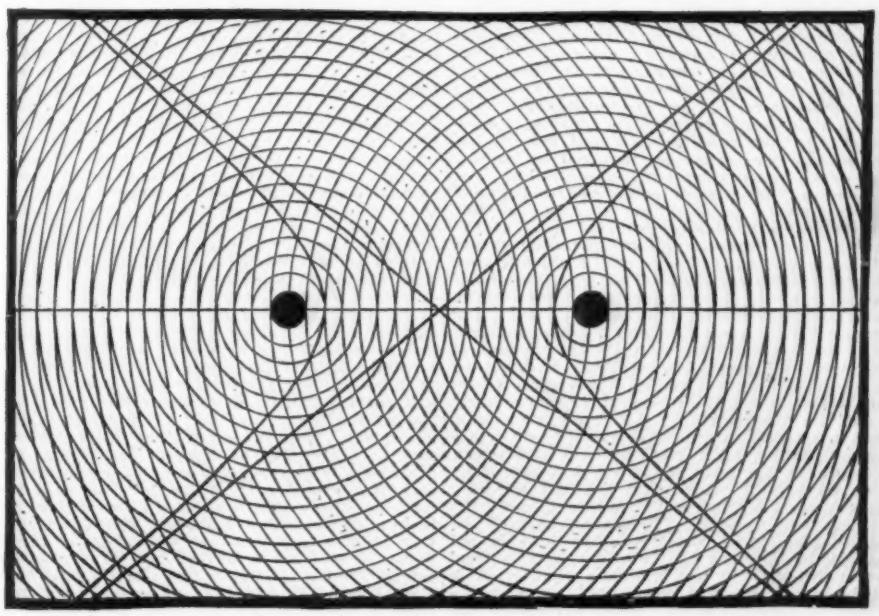


FIG. 2.—DRAWING THE HYPERBOLA.

FLAWS IN STEEL PROPELLER SHAFTS.

AT a recent meeting of the Institution of Engineers and Shipbuilders in Scotland, Mr. Thomas Davison directed the attention of the members to what he considered a peculiar form of corrosion in propeller-shafts. He distinguished it from the ordinary form of corrosion, which has long been observed to take place at the ends of the covering brasses of propeller shafts, and which frequently causes a groove so deep as to render them unfit for use. He gave it the name of "radial corrosion," as it resembled a crack around the shaft, extending toward the center, the corroded part usually having a radiated crystalline appearance quite different, in his opinion, from any fracture produced by mechanical force.

Having, in the course of his experience, met with many failures of iron shafts, he was induced, from not having had a single case of failure in the use of steel, in steel ships, steel boilers, steel shafting, piston rods, and other parts of engines, to advise the use of steel shafts made from one ingot, so as to avoid the flaws and imperfections inseparable from iron shafts made of many pieces welded together. He was disappointed, however, to find that this special kind of corrosion of which he spoke interfered with the use of steel in propeller shafts; and in some cases they were so rapidly corroded that the steel shafts had to be replaced by iron ones until he had time to test the causes of the failure.

As some of his friends did not agree with Mr. Davison in thinking that the flaws in the shafts were caused by corrosion, he wished to give his reasons for his opinion. The shafts which had failed were all of the usual size of iron shafts; their material, as tested by Kirkaldy, was found to have an elastic limit and ultimate strength of over 40 per cent. more than iron; and when tested after corrosion, were found not to have deteriorated. Moreover, it was found that of two shafts exactly similar, one corroded and the other remained perfectly sound, and he inferred that the one was water-tight and the other was not. He illustrated the flaws by many drawings and specimens from shafts, and concluded by urging on engineers the necessity for paying special attention to the subject, so that a remedy might be found for what seems to be the only objection to the use of steel for propeller shafts.

In the discussion which followed the reading of the paper, opinion was divided on the subject, some agreeing with Mr. Davison that the failure of the shafts was

caused by corrosion, others thinking that it was caused by the want of stiffness in the steel. The propellers being overhung, their weight and also their reaction would cause a continual bending and unbending, which, combined with rotation, would rapidly produce the action described by Mr. Davison. Mr. Dick, of the Steel Company of Scotland, had conducted some experiments with rotating pieces of steel subjected to bending action, and he had found that fractures very similar to those described by Mr. Davison were produced. We will not pronounce an opinion on the subject; but as it is one of considerable importance both to steel makers and marine engineers, we will be glad to have the opinions of a few correspondents, that thus we may assist in the attainment of the object Mr. Davison had in view when preparing his paper—that is, the determination of the real causes of the flaws in the shafts.—*Industries.*

COMPRESSED AIR FOR TRAMWAYS.

By Mr. NORMAN SELFE.

MR. NORMAN SELFE, M.I.C.E., recently read a paper on compressed air and its applications, before the Engineering Association of New South Wales, of which institution he has on two occasions been president.

Mr. Selfe introduced his subject by a reference to the comparative merits of compressed air and hydraulic appliances for the transmission of power, and pointed out that, whereas the use of water was a very simple matter theoretically, the compression and expansion of air depended on the complex laws of thermo-dynamics, and that it was only through the researches of eminent scientists, as Joule, Carnot, Rankine, and others, that these laws were made known. Many costly experiments had been made in this colony in the past for producing cold by the compression and expansion of air that were total failures from the want of knowledge on the part of the patentees which was now available for any student. The great and leading features to be constantly borne in mind when dealing with compressed air are the enormous losses of power that occur during compression and subsequent re-expansion when high pressures are worked at. These losses commonly amount to about 70 per cent. of the whole power, and arise thus: First, in the compression of air the whole of the energy exerted to effect its compression is converted into heat, which raises its temperature, and, therefore, its relative volume, and as a consequence the relative power to effect the compression is increased, unless this heat is dissipated as fast as it is produced. In a good compressor as much heat as possible is got rid of during the operation of compressing, and the remainder is dissipated through the walls of reservoirs and pipes as the compressed air returns to atmospheric temperature; so that before the air is employed to work an engine, all the power or heat that was put into it to effect the compression is practically lost. Secondly, in the expansion of compressed air against the piston of an air engine, and the performance of work, the air must part with heat equivalent to the work done (and on this law all cold-air refrigerating machines depend for their action), but this loss of heat brings about a diminution of volume in the air expanded in the cylinder, and a reduction in the work done. It is found that these losses, not so important at low pressures, as, say, 20 lb. to the square inch, but at 40 lb. pressure practical results show the loss to be doubled; and at 10 atmospheres the loss is theoretically double that at 2 atmospheres.

In order to place this part of the subject clearly before the meeting, Mr. Selfe exhibited three large tables which he had compiled from the most eminent authorities, and which showed at a glance, both from theory and practice, the necessity of avoiding high pressure if any economy of power is sought in working with compressed air. After the introduction, the subject was divided into three parts, dealing respectively with the historical or past and present use of compressed air, the principles involved in its use, and some recent improvements in its application. The first part showed that compressed air had been applied as a motive power on tramways as long ago as 1839, and that its use had gradually extended until at the present time there were several systems actually and successfully in use, the principal one of which is that of M. Megarski. This compressed air tram system has been in operation in Nantes since 1879; it has been most favorably reported on by English engineers, and is now running at Holloway, in North London. Megarski uses air at 450 lb. per square inch, Colonel Beaumont at 1,000, some American engineers 3,000 lb., and, as they all seek to carry sufficient stored up air in their receivers to go for long distances, these receivers are enormously heavy, and the greater part of the power given out is employed to draw the machinery, and only a small percentage is available for the traction of the passengers. Again, owing to the great pressures, the power dissipated as heat is so large that artificial warming apparatus is used on the tram engines to keep the whole thing from freezing. The second part of the paper dealt exhaustively with these losses, and showed to what extent and why they were inseparable from the systems hitherto in use, and here another table showed the loss of power which resulted from carrying compressed air through pipes. Great experience has been gained in the Alpine tunnels of Mont Cenis and St. Gothard. The latter is 14,920 meters long, and it is found that with air at 120 lb. pressure, 120 horse power could be conveyed a mile through a 6 in. pipe with a loss approximately of only 5 per cent.; with larger pipes the loss, of course, is proportionately less.

The third part of the paper was really the most important, for here, by means of large diagrams and illustrations, Mr. Selfe showed how, by an invention of Mr. Pardy in America, it is possible for tramway cars to be driven with a very low comparative pressure of air, and thus avoid the enormous loss of efficiency that attends other systems, while at the same time the greater part of the weight of the machinery is done away with. This is effected by laying an air main in the street or road the same as a water or gas main, with suitable valves at intervals, so that by means of a nozzle and flexible tube the driver of the tramcar can replenish his reservoirs with air whenever he stops to put down or take up passengers. In actual practice it was found a car could be charged in a few seconds.

Mr. Selfe then compared the Pardy system with that of M. Megarski, the most successful one yet running, and here we quote the paper in full.

"In order to make a comparison between the merits of Mr. Pardy's tramway improvements and the systems before in use with compressed air, I will take that of Megarski first, because that appears to be the best known, and secondly, because up to the present it has had the largest measure of success. Sir F. J. Bramwell examined into and reported on the Megarski system at Nantes, in France, after it had been in regular work for three and a half years, and he read a very favorable account of it before the Mechanics' Section of the British Association at the Southampton meeting in 1882. It appears that the fuel used for the compressing machinery at Nantes amounted to 1·74 lb. of coal per ton gross of the car weight per mile run, whereas Merryweather's engine did a ton mile with 69 lb. of coal. And drawing conclusions from this, Mr. D. K. Clark, in his last volume on tramways, says: 'While such a contrast can be maintained, it needs but little argument to prove that the direct steam-powered tramway engine is, as it ought to be, the more economical.' Now, I am bold enough to differ with Mr. Clark, for the simple reason that coal consumption is only one factor out of many in estimating the economy of a tramway, and if the cost of motive power was the same in both cases, there would still be no reason why the permanent way should have the extra wear and tear of carrying the boilers and fuel when they could be left stationary, but the comfort of the passengers, the absence of smoke, smell, and steam are all points affecting the economy of the working. Suppose now, however, we make the contrast under the fresh light let in by Mr. Pardy. The Megarski cars, built for the Caledonian Road service of the North Metropolitan Tramway Company, London, carry forty passengers; have their reservoirs strong enough to carry a pressure of 450 lb., and weigh from 6½ to 7 tons empty, or, say, 9 to 9½ tons loaded. A low-pressure car of about the same dimensions, to carry, say, 110 lb pressure, will not require reservoirs of more than one-third the weight of those that carry 450 lb., and the hot-water vessels, with the contained water, will be dispensed with altogether. The car on the Pardy system can thus be reduced in weight to about four tons empty, and say 6½ tons loaded. That is to say, about 70 per cent. of the weight of the high-pressure Megarski car at 9 tons loaded, and a little over 60 per cent. when lightly loaded. The maximum pressure in the low-pressure reservoirs will be nine atmospheres total, and the engines will work at from 15 lb. to 30 lb. above the atmosphere instead of being used at from 75 lb. to 90 lb., as in the Megarski car; and from the larger relative efficiency when working with low-pressure air, an ultimate efficiency of 40 per cent. should be attained in the low-pressure, as against 30 per cent. in the high-pressure car. That is to say, the efficiency in the Megarski system is probably only 75 per cent. of what may fairly be accepted from a low-pressure one. As the relative weights are taken as 70 per cent. fully loaded, and 60 per cent. light, a mean estimate of 65 per cent. is fair for the proportion that the gross weight of the low-pressure car bears to the gross weight of the high-pressure one; and the relative power required for the same weight being 75 per cent., the actual power becomes 75 × 65 — 100, which gives 48·75 per cent., or less than one-half of the power for the low-pressure car of what is required with the higher pressure one."

The writer then shows that hitherto the great aim of designers of air-tramway systems has been to go the maximum distance with a charge of air, and thus the pressures and dead weight have been increased while the efficiency as regards the power employed has got very low—in fact, so as to use from two to three times the fuel of steam locomotives. But with the introduction of an air main along the route the whole conditions are changed. The paper goes on to say: "If large compressing engines of 500 horse power were erected in a favorable situation for getting coal and condensing water, they should obtain an efficiency as prime movers at least twice as good as the present tramway locomotives; and with air cars there should not and need not be more than one-half of the present average dead weight per passenger to put in motion. In such a case, the same work in passengers carried could be done with the same fuel as is burnt now, if the ultimate efficiency of the air engines on the cars was only 25 per cent. of the initial power—that is, if 75 per cent. were lost. For reasons already pointed out, however, a much higher efficiency than this 25 per cent. should result with the low pressure. But surely if the coal bill was 20 per cent. greater than now, instead of less, it would be warranted by the gain in comfort, convenience, and cleaniness, in the absence of steam, smell, and smoke, and in the running of light, handy, and smart cars at much more frequent intervals, and in the reduced wear and tear of permanent way that would result from the substitution of compressed air cars in place of the present lumbering roadway destroyers, with their enormous loads, inconveniences, and dirt *ad nauseam*. Mr. Selfe refers to a proposal made to supply compressed air in Birmingham as water is supplied in London, Hull, and other cities, and shows that there are many obvious advantages, especially for domestic motors, in having air, its ventilating and refrigerating properties when it has done its work especially being desirable. The paper embodies an extract from a report by Mr. Milliken, an engineer of San Francisco, who investigated the low-pressure system for the City Railroad Company of that city, as it was proposed to them to adopt it instead of horses. Mr. Milliken summarizes his investigations with the following table:

COMPARATIVE TABLE, SHOWING THE COST OF PROVIDING AND OPERATING VARIOUS SYSTEMS.

System.	Main line. Cost of providing.	Main line. Daily expenses.	Branch line. Cost of providing.	Branch line. Daily expenses
Horse power*....	$50,000	$150 00	$21,250	$63 75
Cable.....	450,070	203 00	Not available	
Electric.....	375,000	165 00	Not available	
Coal gas.....	130,000	200 00	45,000	120 00
High-pressure air	175,000	164 00	66,000	55 00
Low-pressure....	105,000	125 00	40,000	53 00

* The horse-power system provides for bob-tail cars with only a driver; all the other systems provide for cars for double the capacity, with a driver and conductor.

Mr. Selfe winds up his long and exhaustive paper with a comparison between the cable system, the steam locomotive system in use at present in Sydney, and the low-pressure pneumatic system, and here exhibited large sections of the six principal roads of San Francisco, drawn to the same scale as the principal tram routes of Sydney, to show that the different grades in the two cities make the conditions altogether different for traction. Comparing these three systems with one another, Mr. Selfe concludes thus: Comparison of three systems of tramway propulsion. The rival systems of motive power for tramways most likely to be brought into competition with the low pressure pneumatic system that I have attempted to explain this evening, are: First, the cable roads as so sucessful in San Francisco; and, secondly, our present steam locomotive arrangements. A great deal is often heard about the cable roads of San Francisco, and it has been put forward that they are just the thing for the requirements of Sydney. I know this city well, and I have had every opportunity of becoming acquainted with the tramway system in the capital of the Golden State, both by observation and description; the result is, that I yield to no one in my admiration of the skill and ingenuity of the engineers, as well as of the enterprise and foresight of the capitalists, that have led to their mechanical and financial success; but Sydney is not San Francisco, and the conditions that apply to tramways in these two queen cities of the Pacific are altogether different. First, the cable roads in San Francisco have grades as steep as one in five or six, to work up which no ordinary locomotive, whether air or steam propelled, would be suitable. The six principal cable roads rise over hills from 250 to 300 ft. high, and in several cases pass over two such hills in their run. The latest road up Telegraph Hill is, I believe, about one in three, and only wants tilting a little more when it would not be a tram-road at all, but an elevator, and for such conditions as these I know of no system so suitable as the cable; but although Sydney is a hilly city, as cities go, we have no grades on our tram-roads that locomotives cannot climb, and thus the first motive for a cable road does not exist. Secondly, the cost of cable roads is very great in construction, maintenance, and working expenses. This, in itself, would not be an objection if there was a probability of the earnings being commensurate; but it is not likely to be so, for in San Francisco the conditions do not present, as they do here in Sydney, seven or eight suburban tram lines, all converging to one focus at Liverpool Street, and then, figuratively speaking, running strangled down a side street, to a terminus in a back yard—nowhere. It is unfortunately the fact that through the physical configuration of Sydney something like that is the case here. There in San Francisco the streets are straight, and each separate cable road has its terminus in a populous center of city traffic, and it runs out through main streets which correspond to our George, Pitt, York, King, and Park streets, but on a much larger scale. The tram lines there command also separate avenues of intramural traffic, such, for instance, as is carried in Sydney by the railway omnibuses, and they also perform the greater part of the work that is here done by our surburban railway. There is thus an enormous traffic, and one much more uniform throughout the day than we have here, owing to so many of their leading business streets being traversed by the tramways. Thirdly, it has been estimated in San Francisco that cable, roads cost at least five times as much to construct as horse tramways, and three times as much as a road and air main for the pneumatic tramway. In the case of the cable, it is in constant motion, with its supporting pulleys, and wear and tear is going on whether one car an hour or one car per minute is the service on the track. With an air main there is no wear and tear proper, and no more depreciation then belongs to an ordinary gas or water main. Fourthly, the cable roads consume a large portion of the power exerted to work their own destruction in the wear and tear of cable, which constitutes such a large proportion of the dead weight or non-payable load.

In an able paper on the cable roads of San Francisco, read by Mr. Hanscom before the Technical Society of the Pacific Coast, the average working of seven principal cable roads is summarized thus: Out of the total power exerted by the engines, 68 per cent. goes to move the machinery and cable, 28 per cent. to draw the cars, and 4 per cent. only to carry the passengers. If you give any consideration to these four points in the cable system that I have just referred to, I think you must, as I do, conclude that the conditions for its successful adoption in Sydney do not exist, and so we will next proceed to consider the system we actually have in use.

Under existing arrangements here in Sydney, we commonly have a 16 ton locomotive drawing two cars of a weight aggregating 8 tons, and sometimes 10 tons, or collectively, say, 24 tons of dead weight in a train. And although for an hour or two at morning and evening the cars may be crowded, yet on many lines the average throughout the day is said to be only about twenty passengers. As a basis of comparison, and to give our present system every chance, I will take forty-five passengers instead of twenty as the average load; then, at fifteen persons to the ton, the live load will be 3 tons, which, added to the 24 tons dead weight, makes the total load 27 tons. That is to say, make the best of it, and then only 11 per cent. of the power is exerted to move the passengers, and 89 per cent. is required to drag the dead load about, and destroy the permanent way.

Lastly, under the pneumatic system, where light cars at frequent intervals are proposed, I take for comparison a London metropolitan horse car for forty passengers, which weighs 2½ tons; if to this is added 1 ton of reservoirs, etc., and ½ ton of engines, etc., the weight ready for work becomes 4 tons. Assume it to be only half loaded, or with twenty passengers, at 17 cwt. (I have taken forty-five for present system, remember), the total running weight would be 107 cwt. Of this gross load the 27 cwt. of passengers would be just over 25 per cent., instead of being only 11 per cent., as in the present system with forty-five passengers; but if we consider the air car as fully loaded, or with another 27 cwt., making a total of 6 tons 14 cwt., then the proportion of useful effect or payable load rises to over 40 per cent.

The light air cars can be started every half-hour, every ten minutes, or every minute, according to the

requirements of the traffic; and if they are made to carry no roof passengers, they can be managed with only one man to drive and collect fares, as is done with the bob-tail cars used in some cities. Looking at all these points, I think no hesitation can exist as to the advantages of air cars over our present system. As regards speed, the cable cars cannot run over, say, seven to eight miles per hour; but the air cars have, besides the advantages already enumerated, the further one that they can make up time when on less busy parts of their route, as any reasonable speed is possible with the air system, just the same as when steam is used, but the boilers and fuel are left at the head station; and thus the whole thing runs lighter, and the wear and tear of roads would be due to a maximum of say 30 cwt. on each wheel, instead of 80 cwt. as at present.

With all these advantages, however, I do not expect for some time to see a pneumatic tramway in San Francisco. That city is the home of capitalists and stockholders, who own the cable roads and the cable road patents throughout the United States. In this stock millions of dollars are invested, and such great interests are against a rival system. We all want to see the best system adopted in this city, and my object has been to search for the best system for our wants.

If the Pardy Pneumatic Tramway will stand the criticism of this association, the inventor should have a chance of seeing his cars running here before long. Although for a small traffic on long outlying lines a modified form of steam car may be better adapted, it is not for such a case the Pardy system is proposed, but for our ordinary street tramway work. In conclusion, I have to thank you for your patient attention. Our present tramway system is doomed. It arose under exceptional conditions, and the cry for more means of conveyance in our rapidly extending city and suburbs did not admit of a waiting for experience. After traveling, and seeing the principal tramways in America and England, I consider the low-pressure air system is the best one to take its place.—*The Railway Engineer.*

IMPROVEMENTS IN COKE OVENS.

THE RECOVERY OF PRODUCTS OF DISTILLATION, HEATING GAS, AND COKE FROM COALS OF LITTLE VALUE.

IT will be readily understood that at the present time, when coal tar can almost be had for the mere

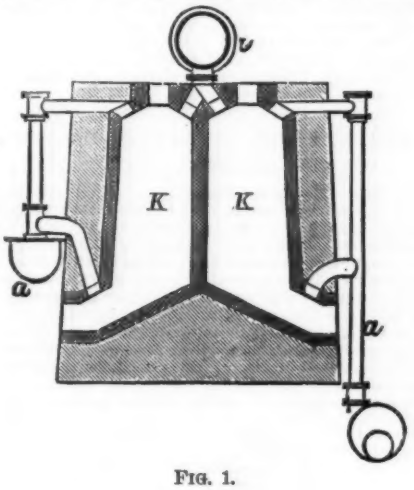


FIG. 1.

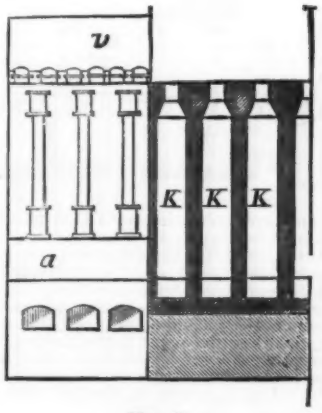


FIG. 2.

COKE OVENS.

trouble of carrying away, those carbonizing operations will be the most likely to pay that have for the principal object the production of coke for metallurgical purposes, in which operations tar may be regarded as a mere by-product. Ammonia, which is often obtained in larger quantity from those coals that are least capable of yielding tar and gas, and which always pays at least fairly well for its recovery, can be looked for in those poorer fuels, even, that are unsuitable for the gas manufacturer and the tar producer. It is a fact that certain coals from Staffordshire deposits, of too slight a bituminous character to serve for gas making, which are, in short, better adapted for steam raising than for that purpose, are not only rich in nitrogen, but on distillation yield that nitrogen very largely in the form of ammonia. It would seem not improbable that the explanation of the large returns of sulphate of ammonia obtainable from such coals, though not very sensibly richer in nitrogen than the more bituminous gas coals, is to be found in the fact that the tar being far less in quantity than that obtained from the gas coals, and also being very thick in character and so poor in oils, *the nitrogen, which would in bituminous coals have gone to form organic nitrogen bases of the pyridine and leucoline* series, besides other nitrogen compounds as yet not understood, has simply had no option, as it were, but to pass off as ammonia.

However, in coking poor qualities of coal, coal dust, slacks, etc., it must be remembered that though a solid or good-looking coke may be obtained, it is open to question, until the contrary be proved by chemical analysis, that this coke will not be rich in sulphur, for coals of the poorer kinds are generally very pyritous.

The object of the patentee, H. Stier (Ger. pat. 35,120, May, 1885; *Dingl. Polyt. J.*, 260, 376–377), is to economize fuel by utilizing the gas obtained from the poor coals in question to fire the ovens. This he does by an arrangement of such a kind that alternately in the

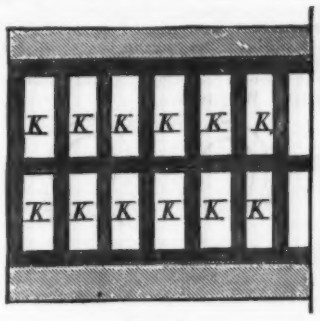


FIG. 3.

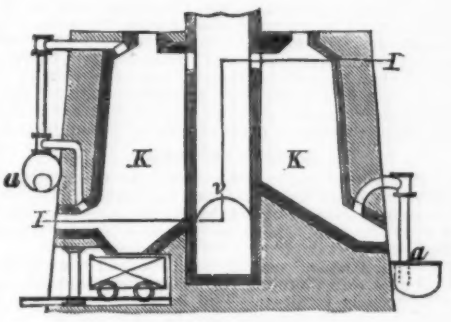
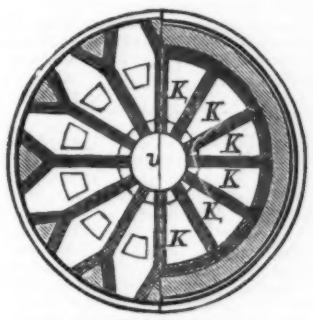
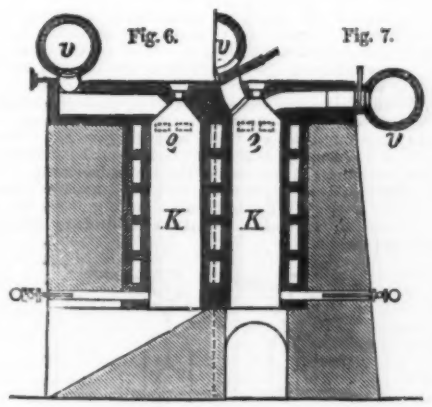


FIG. 4.



Section 1.

FIG. 5.



COKE OVENS.

one chamber of a coke oven a gasification takes place by production of heating gas or by complete combustion; in the other chamber, a destructive distillation in closed space is effected by the heat furnished by the first chamber.

For this purpose, the contents of the ovens, K (Figs. 1, 2, and 3), are being gasified for heating purposes when those of the ovens, K_1, are being distilled for their products, and *vice versa*. Just in the same way the process is conducted as with the usual coke ovens arranged in plan in Fig. 3, and the only difference observed is that in this new arrangement of Stier's the single chambers, K K_1, are only separated by a partition wall, whereas, in the case of the ordinary coke ovens, heating flues are arranged between the single chambers. Figs. 4 and 5 show another arrangement of these new ovens. For example, the gasified products obtained by partial combustion or otherwise in chambers, K, pass, in the case of the usual ovens, through openings, O, into the heating flues (Figs. 6 and 7), carbonizing the contents of the neighboring ovens, K_1, while this latter is effected in Stier's arrangement by means of the thin partition walls separating the chambers, K and K_1, which conduct the heat readily from what may be termed the temporary combustion ovens to the temporary carbonizing ovens. The gasification products are either taken off in the same way as in ordinary working with the combustion gases of coke ovens, or special arrangements, *v*, are fixed to the oven chambers for the purpose.

If the duration of the gasification in, *e. g.*, the chambers, K, that is to say, the heat of their products be sufficient to carbonize several charges in K_1, usually the case when coking coals, the charges first carbonized can be removed, be replaced by fresh ones, and the carbonization continued as long as heat suffices for a continuation of the carbonizing in K_1; then a reversal takes place, the ovens, K, become the carbonizing chambers, and K_1 the combustion or gasification chambers. —*Industries.*

OVAL HOLE CUTTER.

AT the Liverpool Exhibition, Mr. James Lyall, of Liverpool, exhibits Lyall's Patent Oval Hole Cutting Machine, shown by the accompanying engravings; Fig. 1 representing a large machine, capable of cutting an

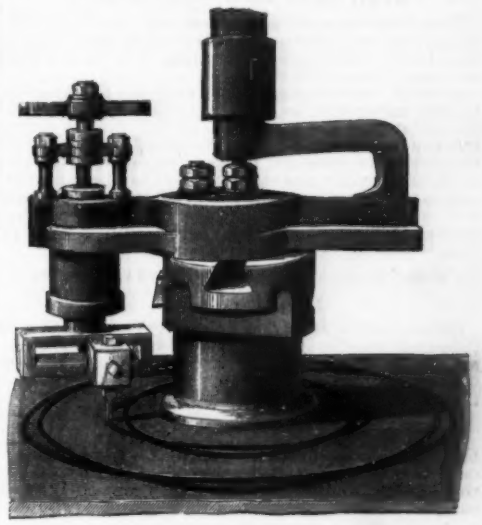


FIG. 1.—LYALL'S OVAL HOLE CUTTING MACHINE.

oval hole from 11 in. by 7 in. up to 21 in. by 17 in., or round holes from 9½ in. up to 19 in. diameter, to be driven by a driving arm fixed into the socket of a vertical boring machine; while Fig. 2 represents a hand-power machine. This machine has a capacity equal to oval holes from 9¾ in. by 5⅝ in. to 18 in. by 14 in., or round holes 7½ in. to 16 in. in diameter.

The larger machine is specially adapted for cutting out man-holes and mud-holes, their doors and compensation rings, donkey boiler firedoors and their openings, bracket plate floors of ships' water-ballast tanks, etc.; the small one serving more especially for cutting oval and round side lights, holes in boilers, girders, tanks, etc.

FIG. 2.—LYALL'S OVAL HOLE CUTTING MACHINE.

The larger machine cuts a hole in an iron or steel plate in twenty minutes which it would take a skilled caiker a whole day to accomplish.

The machine, in either case, is fixed to the plate to be cut by studs passing through two holes bored or punched in the plate on the center line of the major axis of the oval.

The movement of the tool is effected in either machine as follows: Considering Fig. 1, the revolving of the driving arm causes the rotatory arm of the machine, which is fitted with a bush having two holes fitting bolts, with heads sliding in grooves at right angles to one another, to travel before it, and thus impart an elliptical motion to the rotatory arm of the machine, which carries an adjustable cutting tool, fed forward, in this case, by a hand wheel, or star wheel and kicker, the smaller machine being provided with a self-acting feed. By having interchangeable bushes, with the holes to fit the bolts at different distances

apart, the relative lengths of the major and minor axes of the oval to be cut may be varied.

The machines are well patronized by the leading firms, including Messrs. John Elder & Co., R. Napier & Sons, Laird Bros., Wm. Denny Bros., Pearce Bros., etc.

The maker has supplied Messrs. Robert Napier & Sons with a specially made machine of the type shown by Fig. 2, to cut ovals up to 28¼ in. by 21½ in., and rounds up to 25 in. diameter after the plates are in place. They are now using this machine for cutting holes 24 in. diameter through the 2 in. steel decks of the war ships now building for our navy. This machine is driven by a rope pulley, and weighs only 360 lb. A similar machine, but of larger capacity (ovals up to 39 in. by 33 in., and circles up to 36 in.) is at present being made for the Imperial Arsenal at Foo Chow.

Either of the machines illustrated can be made to act as surfacing machines; thus the metal round the hole cut can be truly "faced" by the machine.—*Marine Engineer.*

MAGNETISM AND ELECTRICITY.

EXAMINATIONS OF THE SCIENCE AND ART DEPARTMENT, SOUTH KENSINGTON, LONDON.

THE following are the questions set in Subject IX., Magnetism and Electricity, at the recent examination; examiners, Prof. Frederick Guthrie, F.R.S., and Prof. G. Carey Foster, F.R.S.:

General Instructions.—(If the rules are not attended to, the paper will be canceled.)—You may take the elementary, or the advanced, or the honors paper, but you must confine yourself to one of them. Put the number of the question before your answer. You are to confine your answers strictly to the questions proposed. Your name is not given to the examiners, and you are forbidden to write to them about your answers. The examination in this subject lasts for three hours.

FIRST STAGE OR ELEMENTARY EXAMINATION.

(*Time: Three Hours.*)

Instructions.—You are not permitted to attempt more than eight questions. You may select only two in magnetism, three in frictional electricity, and three in voltaic electricity. The value attached to each question is the same.

Magnetism.

1. If a compass needle is deflected when a steel bar is brought near it, how can you find out whether the deflection is due to magnetism already possessed by the bar, or to the bar becoming magnetized by the compass needle at the time of the experiment?

Answer.—Bring first one end of the bar, and afterward the other end, gradually near to the same end of the suspended compass needle. If attraction ensue in one case and repulsion in the other, we conclude that the bar was magnetized previous to the experiment. If attraction ensue in both cases, we conclude that the bar was magnetized by the compass needle at the time of the experiment. If the deflection in the first case be a repulsion, we may conclude, without further trial, the bar was previously magnetized.

Remarks.—If the bar were merely magnetized by the induction of the compass needle, the magnetizing force being so small, the bar would only be temporarily magnetized, and, therefore, in each case the end presented to the compass needle would become oppositely magnetized to the end of the needle to which it was presented.

It is important that the bar should be brought gradually near to the compass needle, for if it were brought suddenly almost into contact with the needle, it might, if magnetized so that the adjacent ends of the needle and bar were similar, have its magnetism reversed by the inductive action of the needle, and so show attraction instead of repulsion.

2. Two equal bars of steel, after having been equally magnetized, are kept for some years in a vertical position, one, A, with its south-seeking pole upward, the other, B, with its north-seeking pole upward. The bars are so far apart that they do not act on one another; which of the two bars would you expect to find had kept its magnetism best, and why?

Answer.—The bar, A, would keep its magnetism better than the other.

For in this country, being entirely to the north of the magnetic equator, the earth's magnetic force acts in such a direction as to make the north-seeking end of a freely suspended magnetized bar dip downward toward the horizontal, at an angle called the angle of dip, which varies from place to place; and it would act in the same way on the molecules composing the two bars, tending in each case to produce a north-seeking pole at the lower end of the bar and a south-seeking pole at the upper end. Thus the earth's action would assist A to retain its magnetism, but would tend to reverse the magnetism of B.

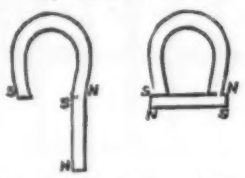
3. You have given to you two rods, one of soft iron, the other of hard steel; also a compass needle and a bar magnet. Describe experiments with the things provided whereby you could find out which was the iron and which the steel rod.

Answer.—Lay the bar magnet on a table, and place one of the bars to be tested close to, or even in contact with, the magnet, S N, and in the same straight line with it. To the end of the bar remote from the magnet bring near the end of the suspended compass needle similar to the pole of the magnet adjacent to the bar; observe whether the compass needle be attracted or repelled. Now, without removing the bar magnet or the compass needle, replace the first bar by the second, and again observe whether attraction or repulsion ensue.

It will be found that in one case there will be attraction and in the other repulsion. The one which attracts the needle will be the bar of hard steel, and the one which repels it will be the bar of soft iron.

Explanation.—The soft iron becomes magnetized by induction while in the presence of the bar magnet, but the effect of the bar magnet on the hard steel will be very small, extending only to the molecules of the bar in immediate proximity to the magnet, and therefore the bar remains practically unmagnetized.

4. A piece of soft iron, placed in contact with both poles of a horse-shoe magnet at the same time, is held on with more than twice the force with which it would be held if it were in contact with only one pole of the same magnet. Why is this?



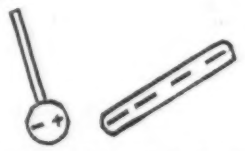
A.—When the piece of soft iron is placed in contact with one pole of the horse-shoe magnet, it becomes magnetized by the induction of the pole with which it is in contact. When the piece of soft iron is in contact with both the poles of the horse-shoe magnet, it is subject to the inductive action of both the poles of the magnet, and becomes more strongly magnetized. The force with which it is attracted by each pole is therefore greater than that with which it was attracted by the single pole in the first case, so that the whole force of attraction of the two poles on the soft iron bar is more than double the force of attraction of the single pole.

Frictional Electricity.

5. A stick of sealing wax, held in the hand and rubbed with dry flannel, is found to become electrified. A brass rod after being treated in the same way shows no electrification. How do you account for the difference?

A.—The stick of sealing wax is a bad conductor of electricity, and therefore the electricity produced upon its surface is retained. The brass rod, on the other hand, is a good conductor, and being in contact with a portion of the human body, which is also a conductor, the electricity flows away as fast as it is produced upon the surface of the rod.

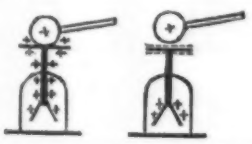
6. A stick of sealing wax, having been rubbed with flannel, is found to be negatively electrified. How, by means of it, would you charge a proof plane with positive electricity?



A.—The proof plane being held by its insulating handle, bring the negatively electrified sealing wax close to its metallic portion (or even in actual contact with it, for the sealing wax, being a non-conductor, will not part with an appreciable quantity of its electricity to the proof plane). The proof plane then becomes electrified by induction, positively on the side near the sealing wax, negatively on the further side.

Connect the proof plane while in presence of the sealing wax to the earth by touching it with the finger, or otherwise, in order to remove the negative electrification, and remove the finger. If the proof plane be now removed from the inductive action of the sealing wax, it will remain positively electrified.

7. If an electrified piece of metal is made to touch a gold leaf electroscope, the leaves separate, and, on taking the metal away, they remain separate. But if the electrified metal is only brought near to the electroscope, and then taken away, the leaves separate when the electrified metal is near, but fall together when it is taken away. Why is there a lasting effect on the gold leaves in one case and only a temporary effect in the other case?



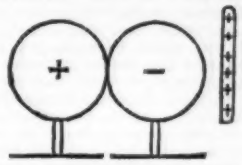
A.—In the first case, the electrified piece of metal (which must, of course, be held by an insulating handle) communicates, by conduction, a portion of its charge to the electroscope, and the charge so communicated to the electroscope remains after the piece of electrified metal is removed.

In the second case, the plate of the electroscope and the upper part of the metal rod which carries the gold leaves become, by the inductive action of the piece of electrified metal, oppositely electrified to it, while the gold leaves and the lower part of the rod become electrified similarly to it. The electroscope, however, receives no absolute charge, and therefore the leaves fall together again when released from inductive action by the removal of the electrified body.

The figure is drawn for the case of positive electrification of the piece of metal.

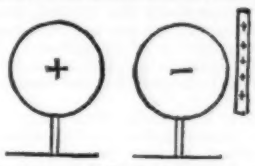
8. Two insulated metal spheres are brought so as to touch one another. A positively electrified glass rod is brought near to one of the spheres, and while it is there the other sphere is taken away. The glass rod is now taken away. On bringing the spheres near together again, a spark passes between them. Give the reason for this.

A.—By the inductive action of the positively electrified glass rod, the nearer sphere becomes negatively electrified and the further one positively.



If the spheres be so parted while under the inductive action of the glass rod, and the rod then removed, their electrifications remain unchanged.

If the spheres be now brought together in the absence of the glass rod, there will be, since they are oppositely electrified, a discharge of electricity from one to the other, which accounts for the spark.



9. To protect a gold-leaf electroscope from being acted on when an electrical machine is at work near it, it is sufficient to cover the electroscope with a thin cotton cloth. How is this?

A.—Since the electroscope is protected from the inductive action of an electrical machine near it by covering it with a cotton cloth, the cloth must be a conductor, as would be the case unless it were perfectly dry, and then it would not protect the electroscope from the action of the machine.

The electroscope may therefore be considered as inclosed within a hollow conductor, and the electricity upon a hollow conductor under the inductive action of *external* electrified bodies distributes itself upon the surface of the conductor in such a manner as to exert no electrical action upon any bodies inclosed within it.

Remarks.—We may note that, whether the inclosed bodies be in electrical communication with the hollow conductor or not, they will be protected from the action of any electrified bodies external to the hollow conductor; and we also know that, even if an absolute charge were given to the hollow conductor by conduction from any electrified body, the charge so given would also distribute itself over the surface of the conductor in such a manner as to exert no electrical action upon bodies inclosed within it.

SYMPATHETIC VIBRATION OF JETS.

THE NEW INVENTION OF C. A. BELL.

MR. CHICHESTER A. BELL, in a paper read before the Royal Society, states that his attention was directed to the subject by the accidental observation that a pulsating air jet directed against a flame caused the latter to emit a musical sound. The pitch of this sound depended solely on the rapidity of the jet pulsations, but its intensity was found to increase in a remarkable way with the distance of the flame from the orifice. In order to study the phenomenon, air was allowed to escape against the flame from a small orifice in the diaphragm of an ordinary telephone, the chamber behind the diaphragm being placed in communication with a reservoir of air under gentle pressure (Fig. 1).

FIG.1.

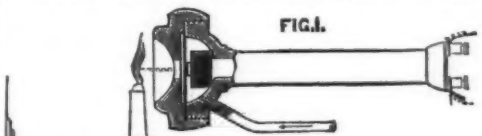
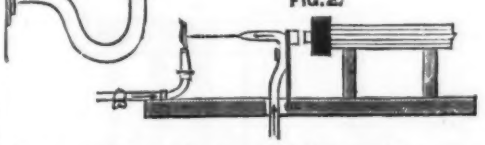


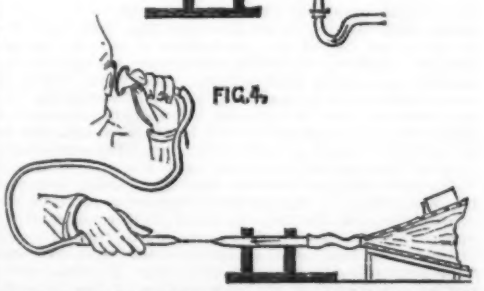
FIG.2.



Vibratory motions being then excited in the diaphragm, by means of a battery and a microphone or rheotome in a distant apartment, the discovery was made that speech as well as musical and other sounds could be quite loudly reproduced from the flame. Certain observations led the author to suspect that motion of the orifice, rather than compression of the air in the chamber, was the chief agent in the phenomenon; and, in fact, precisely similar results were obtained when a light glass jet tube was cemented to a soft iron armature, mounted on a spring in front of the telephone magnet (Fig. 2).

FIG.3.

FIG.4.

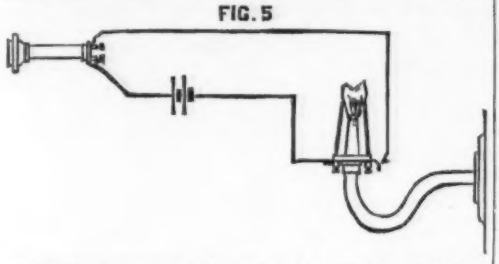


Experiment also showed that an air jet at suitable pressure directed against a flame repeats all sounds or words uttered in the neighborhood (Fig. 3). Except, however, where the impressed vibrations do not differ

widely in pitch from the normal vibrations of the jet (discovered by Sondhauss and Masson), these effects are likely to escape notice, owing to the inability of the ear to distinguish between the disturbing sounds and their echo-like reproduction from the flame.

In these experiments the primary action of the impressed vibrations was undoubtedly exerted on the air jet; but a singular and perplexing fact was that no sound, or at best very faint sounds, could be heard from the latter when the flame was removed, and the ear, or the end of a wide tube connected with the ear, was substituted for it. Suspecting, finally, that the changes in the jet, effective in producing sound from the flame, must be relative changes of different parts of it, the author was led to try a very small hearing orifice, about as large as the jet orifice (Fig. 4). The results were most striking. By introducing this little hearing orifice into the path of a vibrating air jet, the vibrations can be heard over a very wide area. Close to the

FIG. 5



jet orifice they are so faint as to be scarcely audible; but they increase in intensity in a remarkable way as the hearing orifice is moved away along the axis of the jet, and reach their maximum at a certain distance. Experiments with smoked air showed that this point of maximum sound is that at which the jet loses its rod-like character, and expands rapidly; it has been named the "breaking point," because just beyond it the sounds heard from the jet acquire a broken or rattling character, and at a greater distance are completely lost. The distance of the breaking point from the orifice diminishes as the intensity of the disturbing

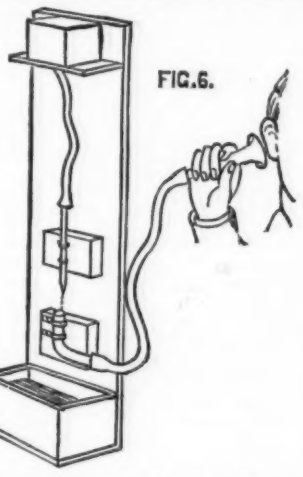


FIG. 6.

vibrations is increased, and also depends to some extent on their pitch and on the velocity of the jet. With orifices of from 1 to 1·5 mm. in diameter, it usually varies from 1 to 6 cm. The vibrations of an air jet may also be heard at points not situated on the axis; but they are always most intense along the axis, and become rapidly fainter as the distance from it increases.

When a vibrating air jet plays against a small flame, the best sounds are heard when the stream strikes the flame just below the apex of the blue zone. At the point of contact an intensely blue flame ring appears, and this ring vibrates visibly when the jet is disturbed. The production of sound from it doubtless depends on changes in the rate of the combustion of the gas. This may be proved by inserting into the ring a fine slip of platinum, connected in circuit with a battery and telephone, shown in Fig. 5.

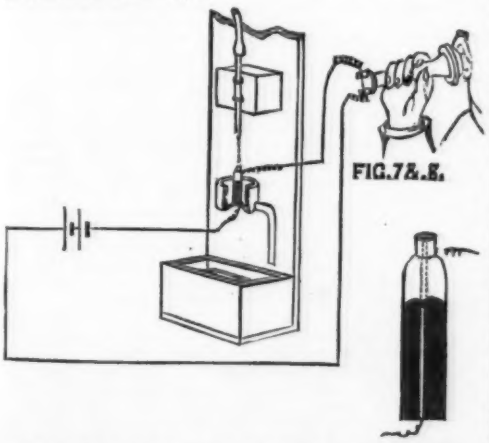


FIG. 7 & 8.

When the jet is thrown into vibration, the consequent variations in the temperature of the platinum affect its conductivity, and hence a feeble reproduction of the jet vibration may be heard in the telephone.

In order to assist the action of aerial sound waves on the fluid, it is advisable to attach the jet tube rigidly to a pine soundboard about three-eighths of an inch thick. The surfaces of the board should be free, otherwise it may be supported in any way. The receiving membrane is formed by a piece of thin sheet rubber tied over the end of a brass tube about three-eighths of an inch in internal diameter. A wide flexible hearing tube, furnished with an ear-piece, is attached to the brass tube. The jet tube is connected with an elevated reservoir by an India-rubber pipe, indicated in Fig. 6; with an apparatus of this kind and a tolerably wide jet tube, having an orifice about 0·7 mm. in diameter, a pressure of about 15 decimeters of water is required to bring the jet into condition to respond to all the tones and overtones of the speaking voice (except hissing sounds) and those employed in music. At a somewhat higher pressure it will reproduce hissing sounds.

To get an accurate and faithful reproduction of the jet vibrations, it is simply necessary to insert into the nappe two platinum electrodes in circuit with a telephone and a battery having an electromotive force of from 12 to 30 volts. Loud sounds can thus be obtained from a jet which is finer than the finest needle, and the arrangement constitutes a highly sensitive "transmitter," shown in Figs. 7 and 8.

The foregoing are little more than the outlines of a new theory of jet vibrations. The author hopes to supply in the future further experimental evidence in support of it.

THE ORIGIN OF ELECTRICITY IN STORM CLOUDS.

WE are, as yet, far from being decided as to the origin of electricity in storm clouds, and the numerous scientists who have studied the question have, for the most part, expressed different opinions.

A communication from Mr. D. Colladon to the Academy of Sciences furnishes a very interesting theory in regard to this subject, and one which, moreover, is based upon the results of experiment. We shall give a brief analysis of it.

Sometimes, those clouds which are distinguished by a rapid succession of numerous flashes do not remain stationary, but move with a velocity of from 18 to 30 or more miles per hour, usually from southwest to northeast. Thus, for example, a very heavy electric storm, accompanied with a considerable fall of hail, which traversed the canton of Geneva on the night of July 7–8, 1875, and in which the mean number of flashes exceeded 60 per minute, traveled from the valley of the Saône to Geneva with a velocity of 33 miles per hour, and from Geneva to St. Maurice, in Valais with a decreasing intensity and a mean velocity of about 27 miles.

In a storm observed by Mr. Colladon, on the 17th of last July, at Geneva, the stormy group remained nearly stationary for two hours and a half, and during this interval furnished five or six thousand flashes, and spread over the earth an enormous quantity of electricity in a visible and invisible form, from a circumscribed part of the atmosphere. Whence and how was this incessant flow of positive electricity kept up for all this time? How were these clouds, which were nearly exhausted after each flash, continually recharged in so short a time and for so long a period?

Mr. Colladon does not share the opinion of Prof. Palmieri, who attributes the abundant production of electricity in storm clouds to a condensation that collects the aqueous particles into drops of rain, and concludes therefrom that every cloud that resolves itself into rain is a continuous source of electricity; but gives another reason for the phenomenon. Like Mr. Faye, he explains it by a continuous draught of air from above the storm clouds; but he does not think that this draught is due to the gyratory and other motions that invariably manifest themselves in storms, for very numerous cases may be cited in which the storm cloud long remained stationary, and in which the draught of air was essentially due to a shower—the only apparent cause of the continuous renewal of the electricity of clouds, and sometimes also of the congelation of their rain drops into hail stones.

According to Mr. Luvini, a factor of great importance consists in the disengagement of electricity produced by the friction of moist air against cirri, and the aqueous particles that surmount the clouds; but this very electrification supposes, in the first place, an upper draught of air, and, moreover, a violent disturbance of the latter that prevents the immediate reunion of the two momentarily separated electricities. Mr. Colladon holds pretty much the same opinion, but thinks that Mr. Luvini attributes much too exclusive a role to gyratory draughts.

He gives a new explanation of the prime cause of the multiplicity of flashes from some stationary or moving clouds, and of the showers of sleet and hail that sometimes accompany them.

The following are the theoretic ideas that the author takes as a basis to explain satisfactorily, and in many cases, that singular persistence of storm clouds in a state of high electric tension, continuously exhausted and renewed.

Every nearly vertical fall of water produces a consecutive wind directed toward the earth. It is this same vertical wind that is often utilized for producing a downward compression of the air contained in the apparatus called a tromp—such air being driven into a reservoir and serving to supply blowing apparatus. As well known, also, every cascade produces a strong current of descending air, which, spreading over the earth, gives rise to what has been styled a cascade wind—a wind which, in powerful waterfalls, constitutes, in certain cases, a genuine hurricane toward the base of the fall. So, too, every rain drop is the origin of an elementary vertical current of air that takes rise where the rain is beginning to fall, that is to say, in the interior of the cloud. The larger the rain drop, the more notable is the elementary current of air. Every shower, then, necessarily carries with it a descending wind, whose starting point is situated in that very part of the cloud where the rain drops form. The intensity of this wind increases with the heaviness of the shower.

On another hand, as the rain does not cease to act in a downward direction upon the air that it carries along until the moment that it reaches the earth, it is only there that it will be set free and will escape laterally without any possibility of its rising to the cloud whence it came. In this cloud, and in the very sources where the rain forms, there will occur, then, a notable depression of the atmosphere, which must, of necessity, be compensated for by a foreign draught of air. This latter can come only from above or from the side; but if the diameter of the column of rain be very wide, a lateral draught will not be possible, and the depression in the cloud will therefore be made good only by a flow of air attracted from the atmospheric stratum above the cloud that furnished the rain drops.

Now, it is universally recognized that this stratum of air is in every season positively electrified with respect to the earth. So, when the rain clouds are very dense and high (which is something that frequently happens in summer), the air attracted from the upper zones will necessarily bring with it a constantly renewed supply of positive electricity, needles of ice, and globules of very cold water. This mixture of ice needles and globules of water below zero will be more than sufficient to counterbalance the reheating of the upper air produced by its increase in density, and the mean temperature of the rain cloud will fall much below zero.

In all cases in which we can admit the existence of a vast tromp that carries the upper strata of the atmosphere toward the earth, these theoretical considerations will suffice to explain those two meteorological phenomena, the cause of which has so long remained obscure, to wit:

1. The rapid renewal of electrical tension in the majority of storm clouds, despite the continual discharges of their electricity into the earth, either whether they manifest themselves by a succession of flashes and thunder claps, or whether their occurrence is invisible because of the great electric conductivity of the lower air, strongly charged with rain and dampness.

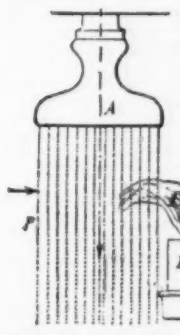
2. The accidental formation of the sleet and hail that occur, especially in the months of July or August, when the clouds possess their maximum density and elevation. We know, in fact, that during the hot season, storm clouds have an elevation of over 10,000 feet, and cases have been noted where the elevation exceeded 16,000 feet.

Upon the whole, according to Mr. Colladon, there is a draught of air in the storm cloud that occurs laterally when the column of water is of slight diameter, and that comes from above when the column covers a wide area.

The accuracy of this hypothesis is easily verified. The cascades of the Pont-du-Diable, at Saint Gothard, and of Salence, in Valais, present a very fine example of lateral draught, which, moreover, is something that is to be seen in most large cascades. During foggy weather, by looking over the top of these waterfalls, it is easy to see portions of the fog attracted by the fall, and descending with considerable velocity.

Finally, it is possible to experiment, on a small scale, in regard to downward and lateral draughts, by means of the two very simple apparatus figured herewith. The first of these has the shape of the rose head of a shower bath. From this rose, A, a shower, *pp*, is al-

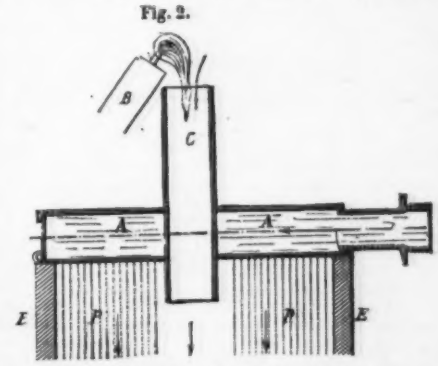
Fig. 1.



lowed to fall vertically. If, while the water is falling, we bring a lighted candle, B, near, we shall see the flame, *f*, attracted to the water. The draught is especially perceptible at a few fractions of an inch below the rose. The air, sucked in laterally around the circumference of the shower, serves to replace that which the drops of falling water are continuously carrying downward.

The other apparatus (Fig. 2) is designed for imitating,

Fig. 2.



on a small scale, the draught of air which showers of a certain extent produce above their starting point. In this apparatus, the rose is replaced by a reservoir, A, which is in the form of a flattened cylinder of wide diameter (6 or 10 inches). The sides of this reservoir are traversed by a central tube, C C, open at both ends. Numerous apertures are arranged in a circle around the tube, C, in the lower surface of A. Finally, there is an external envelope of cloth, E E, for preventing any lateral draught.

The reservoir, A, being placed horizontally, and water being let into it, a ring-shaped shower will fall, and produce at the top of the tube, C, a suction of air that may be made visible by bringing the flame, *f*, of the candle, C, near the upper orifice of the tube, C.—*Revue Industrielle.*

FOR the manufacture of a white ink that can be used in a ruling pen as India ink is used: Mix Chinese white with water containing enough gum arabic to prevent the immediate settling of the substance. Magnesium carbonate may be used in a similar way. They must be reduced to impalpable power.

OLIVER WENDELL HOLMES.

By Samuel Wilks, M.D., F.R.S.

The literary fame of Oliver Wendell Holmes is too well established to require any enforcement on the occasion of his visit to this country, but his connection with the medical profession gives especial interest and zest to his writings for those who are of a like calling with himself. In this respect our author takes an almost unique position; for although it is true that literature has numbered among its devotees men who had been students of medicine, yet in most cases one profession has been discarded for the other, as in the examples of Smollett, Goldsmith, Keats, and others, where the doctor's craft was scarcely seen to gild their writings.

With Wendell Holmes it is very different; for although he had long retired from the active pursuits of his profession, he had retained until lately the professorial chair, and therefore ever had before him whatever the anatomy and physiology of the human body could teach, and their lessons are evident in every page of his writings. It is from this point of view I venture to give a few extracts from his works which come ready to hand as samples of his method. When it is remembered how intimately associated is the material structure of our frames with all those characteristics of men and women which we call mental, moral, or religious, it is obvious how much deeper and clearer must be the insight into human nature by one who has a profound knowledge of the sources from which many of them spring. How intimately states of health, forms of disease, or inherited temperaments affect the mental and moral qualities, every medical man knows; but how often do we see them entirely overlooked or ignored by those who are regarded as our leading novelists or poets! At least this was so with many writers of the last generation, where the material basis and all the coarser functions of the body were hidden, to give place to the more refined and elevated passions of the mind. A severance of this kind of natural phenomena has led to a reaction in the production of the realistic school, and we see the result in much of our modern literature, painting, and the drama. It has already reached its climax in certain French and English novels, in which the loathsomeness of the descriptions is usually sufficient to cause the reader to close their pages.

Some of those who have protested against the modern realistic school have very unfairly dragged some of our profession into the mire, and have associated distinguished scientific men, whom they have been good enough to style materialists and vivisectionists, with those who can depict the horrible details of a murder on an immense canvas in the *salon*, or describe minutely the filthy particulars of the animal functions in a French novel. Wendell Holmes is a living protest against so gross a charge. These critics fall into the error of confounding the act of dissection with its exposure to the public eye. It need not here be said that those who wish to learn the intimate structure of the human body must remove the outer skin to enable them to discover the mechanism within; but the sight is not a pleasant one to the uninitiated eye, and the investigation is considerately kept from the public gaze. In a similar way, in order to obtain a perfect knowledge of all that pertains to the faculties, feelings, desires, and passions of the human being, the whole nature of men and women must be dissected or unraveled, so that those who have discovered the intimate connection between the influences of a material kind and such passions as love and hatred are in the best position to portray human nature in all its attitudes. It by no means, however, follows that Zola need describe with the most minute details all the lower animal functions which the instincts command us to keep secret. Let him make the analysis if he pleases, and even use it in furtherance of his object, but he need not expose the details to public view. Balzac had no need to do this, and yet no writer shows a deeper insight into character as expressed in the ever-varying form and features.

Wendell Holmes has such a knowledge of the human frame as none but a good anatomist, physiologist, and pathologist could possess. His knowledge is apparent in every page of his writings, and gives to them their special value; yet a true artist's aim can be accomplished, and he no more ruffles the sensibilities than does Dickens in describing the very scum of our streets. In his last novel, "Mortal Antipathy," it is evident that he is cognizant, and has indeed a very large experience, of those animal and sexual instincts which go to make or mar much human happiness. That his mind is quite alive to the subject we see in his "Life of Emerson," where he says: "When Zola and his tribe cross the borders of science into its infected districts, leaving behind them the reserve and delicacy which the genuine scientific observer never forgets to carry with him, they disgust even those to whom the worst scenes they describe are too wretchedly familiar. The true realist is such a man as Parent du Chatelet, exploring all that most tries the senses and the sentiments, and reporting all truthfully, but soberly and chastely, without needless circumstance or picturesque embellishment, for a useful end, and not for a mere sensational effect." Although on the authority of our hero the dissection need not be exposed to public gaze, it does enable the investigator to understand more thoroughly the beings with which he is dealing, and to see how all mankind are one, and how "one touch of nature makes the whole world kin."

With Wendell Holmes this has produced a sympathy with his fellow creatures which is one of the most characteristic features of his writings. "I do not know," he says, "what special gifts have been granted or denied me, but this I know, that I am like so many other of my fellow creatures that when I smile I feel as if they must; when I cry, I think their eyes fill; and it always seems to me that when I am most truly myself I come nearest to them, and am sure of being listened to by the brothers and sisters of the larger family into which I was born so long ago. I have often feared they might be tired of me and what I tell them. But then, perhaps, would come a letter from some quiet body in some out-of-the-way place which showed me that I had said something which another had often felt but never said; or told the secret of another's heart in unburdening my own." In another place he says: "A writer is like a lover; and a talk with the right listener is so like an arm-and-arm walk in the moonlight, with the soft heart-beat just felt through the folds of muslin and broadcloth. I have no doubt each one of us has somewhere our own facsimile, so like in all things except the accidents of condition that we should love each other like a pair of twins if our nature could once fairly meet. I know I have my counterpart in some State of this Union. I feel sure that there is an Englishman somewhere precisely like myself (I hope he does not drop his H's)." In "The Poet," also, he says: "Self-revelation from unknown and sometimes nameless friends, who write from strange corners, where the winds have wafted some stray words of theirs, which have lighted in the minds and reached the hearts of those to whom they were as the angel that stirred Bethesda. This is the best reward of authorship; it may not imply much talent and literary excellence, but it means that your way of thinking and feeling is just what some of your fellow creatures needed."

His general scientific culture, enabling him to take into his regard the whole organic world, gives a much wider range to his vision, so that he has a truer grasp of human character than most writers. It is for this special reason I have taken up my pen, for it has not been sufficiently appreciated by most of his literary critics. In an early page of "The Autocrat," he describes how he had seen singers and pianoforte players making such strange motions that he laughed at them, and asked himself where they picked up these fine, ecstatic airs; but when he went home, he found his Canary bird piping its little tunes and swimming and waving about with all the droopings and liftings and languishing side-turning of head that he had been laughing at.

He then asked himself who taught all this, and found that he had erred in passing a judgment upon a creature made of finer clay than himself. Wendell Holmes sees that all nature is one, and the same laws are operating through not only the animal but the vegetable world. The following passage I have more than once read to mothers who had not perceived that a time comes when their daughters are pining to leave the nest: "You may know that from the earlier stages of development of almost any vegetable you only want air, water, light, and warmth. But by and by, if it is to have special complex principles as a part of its organization, they must be supplied by the soil; your peas will crack if the root of the tree gets no iron; your asparagus bed wants salt as much as you do. Just at the period of adolescence, the mind often suddenly begins to come into flower and to set its fruit. Then it is that many young natures, having exhausted the spiritual soil around them of all it contains of the elements they demand, wither away undeveloped and uncolored unless they are transplanted." In another place he says men often remind him of pears coming to maturity: "Some are ripe at twenty, like human Jargonelles, and must be made the most of, for their day is soon over; some come into their perfect condition late, like the autumn kinds, and they last better than the summer fruit; and some, like the winter Nelis, have been hard and uninviting until all the rest have had their season, yet their glow and perfume last long after the frost and snow have done their worst with the orchards."

The subject of evolution is before him when he describes an old black woman, "bent up, wrinkled, yellow eyed, with long upper lip, projecting jaws, retreating chin, still, meek features, long arms, large, flat hands, with uncolored palms and slightly webbed fingers; it was impossible not to see in this old creature a hint of the gradation by which life climbs up through the lower natures to the highest human developments." In "The Poet" he says: "The scientific study of man is the most difficult of all branches of knowledge. It requires in the first place an entirely new terminology, to get rid of that enormous load of prejudices with which every term applied to the malformation, the functional disturbances, and the organic diseases of the moral nature is at present burdened.

"Take that one word 'sin' for instance; all those who have studied the subject from nature, and not from books, know perfectly well that a certain fraction of what is so called is nothing more or less than a symptom of hysteria; that another fraction is the index of a limited degree of insanity; that still another is the result of a congenital tendency which removes the act we sit in judgment upon from the sphere of self-determination, if not entirely, at least to such an extent that the subject of the tendency cannot be judged by any normal standard." In another place he says: "You must have comparative theology as well as comparative anatomy. What would you make of a cat's little good-for-nothing collar-bone if you did not know that the same bone means a good deal in other creatures. You cannot know too much of your race and its beliefs if you want to know anything about your Maker. I never found but one sect large enough to hold the whole of me." "And may I ask what that was?" "The human sect, including cannibals and all." Running through all his writings is the horror expressed at the idea of responsibility being attached to us for the sins of our forefathers.

"Elsie Venner" was written with a theological moral to show his disbelief in a new-born infant being responsible for other people's acts, and suggests that Æsop's fable of the "Wolf and the Lamb" may have been written to denounce such a doctrine. Speaking of his heroine in the "Guardian Angel," he says: "The instincts and qualities belonging to the ancestral traits which predominated in the conflicts of mingled lives lay in the child in embryo waiting to come to maturity. It was as when several grafts bearing fruit that ripens at different times are growing upon the same stock. Her earlier impulses may have been derived directly from her father and mother, but all the ancestors who have been mentioned, and more or less obscurely many others, came uppermost in their time before the absolute and total result of their several forces had found its equilibrium in the character by which she was to be known as an individual. These inherited impulses were therefore many, conflicting, some of them dangerous; the World, the Flesh, and the Devil had mortgages on her life before its deed was put into her hands." In the same train of thought, he says: "So much are our minds alike, and yet you and I think we are peculiar, and that Nature broke her jelly-mould after shaping our cerebral convolutions."

Not only does Wendell Holmes make use of his professional knowledge in the portrayal of character, but he prominently brings forward the medical man in his various writings as one of the most important elements in the social community. He makes him honest, kind-hearted, and possessed of more than ordinary worldly wisdom. The following is from "Elsie Venner": "I have heard it said that the art of healing makes men hard-hearted and indifferent to human suffering. I am willing to own that there is often a professional hardness in surgeons, just as there is in theologians, only much less in degree than in these last. While I am writing this paragraph there passes by my window on his daily errand of duty, not seeing me though I catch a glimpse of his manly features through the oval glass of his chaise as he rides by, a surgeon of skill and standing so friendly, so modest, so tender-hearted in all his ways, that if he had not approved himself at once adroit and firm, one would have said that he was of too kindly a mould to be the minister of pain, even if it were saving pain.

"You may be sure that some men, even among those who have chosen the task of pruning their fellow-creatures, grow more and more thoughtful and truly compassionate in the midst of their cruel experience. They become less nervous, but more sympathetic. They have a truer sensibility for others' pain, the more they study pain and disease by the light of science." His remarks about medical men are always to the point. He says: "If you are to make choice of a physician, be sure you get one, if possible, with a cheerful and serene countenance.

"A physician is not, at least ought not to be, an executioner; and a sentence of death on his face is as bad as a warrant of execution signed by the governor. As a general rule, no man has a right to tell another by word or look that he is going to die. If you will only let nature and the God of nature alone, persons will commonly learn their condition as early as they ought to know it, and not be cheated out of their natural birthright of hope and recovery." This advice by no means prevents his perceiving the moment when the doctor's presence may give place to that of others, for he says: "Do not overlook the desire for spiritual advice and consolation which patients sometimes feel, for as part of medical treatment it is the physician's business to detect the hidden longing for the food of the soul as much as for any form of bodily nourishment."

In speaking of the different features of persons, he says: "It is the same thing with a patient; his disease has features of its own; there never was, and never will be, another case in all respects exactly like it. If a doctor has science without common sense, he treats a fever, but not this man's fever; if he has common sense without science, he treats this man's fever without knowing the general laws that govern all fevers and all vital movements. The men who have science only begin too far back, and before they get as far as the case in hand, the patient has very likely gone to visit his deceased relatives."

In one of his novels he describes the doctor as "sixty-three years old, a bald crown, as every doctor should have; a consulting practitioner's mouth—that is, movable round the corners while the case is under examination, but both corners well drawn down and kept so when the final opinion is made up. . . . Some very silly people thought the old doctor did not believe in medicine because he gave less than certain poor half-taught creatures in the smaller neighboring towns, who took advantage of people's sickness to disgust and disturb them with all manner of ill-smelling and ill-behaving drugs. To tell the truth, he hated to give anything noxious or loathsome to those who were uncomfortable enough already, unless he was very sure it would do good; in which case he never played with drugs, but gave good, honest, efficient doses." His medical or physiological knowledge is constantly cropping up in his descriptions of persons and their doings: "Ah! it is the pale passions which are the fiercest; it is the violence of the chill that gives the measure of the fever.

"The fighting boy of our school always turned white when he went out to a pitched battle with the bully of some neighboring village; but we know what his bloodless cheeks meant; the blood was all in his stout heart; he was a slight boy, and there was not enough to redden his face and fill his heart both at once." A poor fellow who is ill and full of pain is not in a condition to judge fairly, and his friends cannot accept his verdict: "Many an honest ignorant man has given us pathology when he thought he was giving us psychology. It is a remark which I have heard from the wise patriarch of the medical profession among us, that the moral condition of the patients with disease *above* the great breathing muscle—the diaphragm—is much more hopeful than that of patients with diseases *below* it—in the digestive organs." In speaking of poor little children, who are often made the subjects of persecution by well meaning religious people, Holmes says of one of them who had escaped: "The child would have died, no doubt; and if properly managed, might have added another to the long catalogue of wasting children who have been so cruelly played upon by spiritual physiologists, often with the best intentions, as ever the subjects of a rare disease by the curious students of science. . . . I have no doubt that disgust is implanted in the minds of many healthy children by early surfeits of pathological piety.

'I do verily believe that He who took children in His arms and blessed them, loved the healthiest and most playful of them just as well as those who were richest in the tuberculous virtues." He uses similar medical expressions in speaking of a girl who was in a prolonged hysterical state: "The poor little soul had been in one of those trances that belong to the spiritual pathology of higher natures, mostly those of women." That he knows, however, what hysteria is, the following will prove: "The young girl looks innocent enough; but what does a blush prove, and what does its absence prove, on one of those innocent faces? There is nothing in all this world that can lie and cheat like the face and the tongue of a young girl. Just give her a little touch of hysteria—I don't mean enough of it to make her friends call the doctor in, but a slight hint of it in the nervous system—and Machiavelli might take lessons of her."

The study of women in all their nervous vagaries has been a favorite one with Holmes, and he has a humorous and telling way of exemplifying great truths as few other writers have. Every one knows how in emotional conditions laughing and crying are associated, or that allied movements of the chest are the manifestations

of both of them. Holmes puts it thus: "Laughter and tears are meant to turn the wheels of the same machinery of sensibility—one is wind power and the other water power, that is all." He is very fond of likening the human form to a machine, thus: "Our brains are seventy-year clocks The Angel of Life winds them up once for all, then closes the case and gives the key into the hand of the Angel of the Resurrection. Tic-tac! tic-tac! go the wheels of thought; our will cannot stop them; they cannot stop themselves; sleep cannot still them; madness only makes them go faster; death alone can break into the case, and, seizing the even swinging pendulum which we call the heart, silence at last the clicking of the terrible escapement we have carried so long beneath our wrinkled foreheads."

"Then mark the cloven sphere that holds
All thought in its mysterious folds,
That feels sensation's faintest thrill,
And flashes forth the sovereign will;
Think on the stormy world that dwells,
Locked in its dim and clustering cells,
The lightning gleams of power it sheds
Along its hollow glassy threads."

The expressions gained from medicine are often very applicable and amusing. Holmes says when he was young he always avoided a story with a moral, and yet in his later years he had written a couple of "medicated novels"; "Now take a poet like Cowper; he had a mental neuralgia a great deal worse in many respects than tic doloureux, confined to the face. . . . Many women die worried out of life by the perpetual teasing of an inflamed neuralgic conscience." At an entertainment he speaks of the first laugh which "broke out as premature; it was a sporadic laugh, and did not become epidemic." He is too polite and too loyal to the profession to make a coarse joke at its expense, but in speaking of a lady in one of his works he says: "Her daughter had also married well, to a member of what we may call the post-medical profession—that, namely, which deals with the mortal frame after the practitioners of the healing art have done with it and taken their leave." His allusions are often like this, merely suggestive, but consequently the more humorous, as when speaking of the old hall "with the sculptured, unpunishable cherubs over its portal." Wendell Holmes has written very little which can be called purely medical. Some years ago he contributed to journals papers on puerperal fever and on the microscope. He coined, I believe, the term *cutis ænea* for Addison's disease. His other writings were of a literary kind, but many tinctured by if not founded on his physiological reflections; as, for example, a very interesting article on the "Physiology of Versification and the Harmonies of Organic and Animal Life," showing how rhythm, meter, accent, etc., depend on respiration and the circulation.

As the subject of wine drinking is always under discussion, we will hear what our author says in its favor in one respect, that is, its use at dinner in equalizing divergent tempers and rubbing off asperities: "Whatever may be the hygienic advantages or disadvantages of wine, I, for one, except for particular ends, believe in water, and, I blush to say it, in black tea; there is no doubt about its being the grand specific against dull dinners. A score of people come together in all moods of mind and body. The problem is, in the space of one hour, more or less, to bring them all into the same condition of slightly exalted life. Food alone is enough for one person, perhaps talk alone for another; but the grand equalizer and fraternizer which works up the radiators to their maximum radiation, and the absorbents to their maximum receptivity, is now just where it was when six great vessels containing water were changed into the best of wine."

Wendell Holmes has been called poet, litterateur, and scientist, and this combination of talents in the same man proves that science and letters need not be divorced. It is a melancholy thing to observe with what distaste many literary men regard what they call science, and how they associate with it all that is degrading and unrefined. Goethe stands out a grand example that there is no necessary antagonism between the two; and now we have Holmes, a living man, who possesses to a large extent a knowledge of all the material facts belonging to man's nature, while he, nevertheless, can carry them into the higher regions of poetry and religion. He himself is aware of this feeling which exists among men of letters and poets, for in his "Life of Emerson" he speaks of poets looking askance at science, and how Emerson contrasts learned men with their glasses with the sons of nature, much to the disadvantage of the microscopic observers.

Holmes says that he notices the poet is curious and asks all manner of questions, but never thinks of waiting for the answer, still less of torturing nature to get at it. Emerson wonders, for instance, when looking at flowers, "why nature loves the number five," but leaves his note of interrogation without troubling himself any further. Wendell Holmes shows that this might have been answered without any loss to his poetical mood, for, speaking of a character in "The Guardian Angel," he says: "It seemed as if nothing of all that he met in his daily life was uncommon or unclean to him, for there was no mordant in his nature for what was coarse or vile, and all else he could not help idealizing into its own conception of itself, so to speak. He loved the leaf after its kind as well as the flower, and the root as well as the leaf, and did not exhaust his capacity of affection or admiration on the blossom, upon which his friend the poet lavished the wealth of his verse."

No writer that I am acquainted with can combine like Wendell Holmes the real facts of nature with all which religion or poetry is craving after. He can describe the burial of the young girl under the tree, together with the decomposition of the body, and the further chemical changes which tend to the growth of the plant; and with this he does not hide ideas which might suit the believer in metempsychosis or the Christian:

"At last the rootlets of the trees
Shall find the prison where she lies,
And bear the buried dust they seize
In leaves and blossoms to the skies:
So may the soul that warm'd it rise."

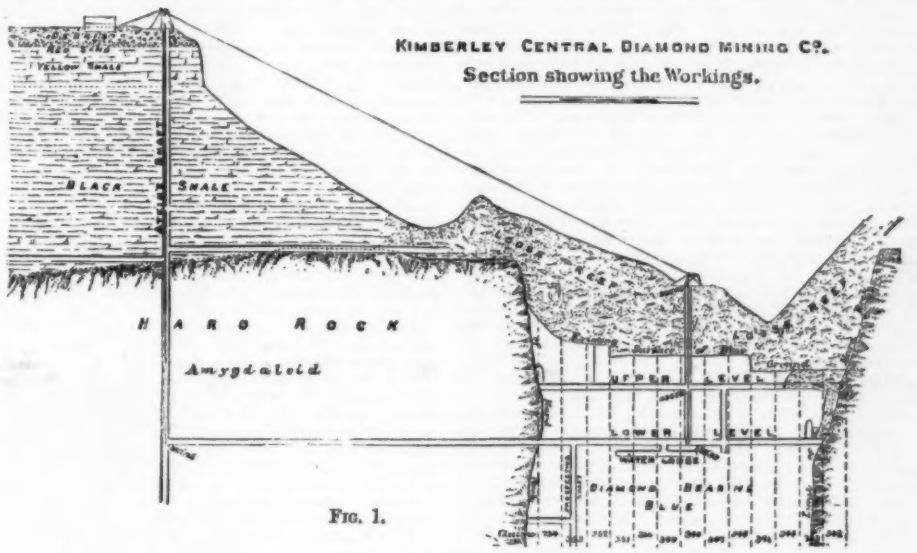
Probably all that I have said and all the quotations which I have given are known to the admirers of Wendell Holmes, but there are many I find in our profession who are less acquainted with his works, and are ready to applaud because one among their number has distinguished himself outside medicine in the walks of literature. It is, however, because he has combined two professions, or rather made use of his medical learning in the portraiture of character, and thus in my opinion elevated the standpoint of the novel writer, that his superexcellence is seen. In this respect Dr. Oliver Wendell Holmes stands unique. I have no hesitation in stating my belief that the raciness of his writings, with the subtlety of thought comparable only with "Tristram Shandy," as being ever true to nature, will make them always live. The man himself has ever been the subject of love and affection. The words of the Laureate might well apply to him:

"A life that all the muses deck'd
With gifts of grace, that might express
All-comprehensive tenderness,
All-subtilizing intellect."

—*The Lancet.*

AFRICAN DIAMOND MINING.

UNTIL comparatively modern times, the diamond does not appear to have been possessed by any except those of the highest rank. Pliny states that it bore a price above all things in the world, and was known to very few except princes and crowned heads. India appears to have been almost, if not quite, the only source of supply until the last century. In 1728, however, Brazil came into competition with Golconda's famed and famous shores as a source of supply. There were also at intervals occasional diamonds found in Borneo. During the present century, Brazil and the Ural Mountains have been the principal contributors to the already known diamond wealth of the world, the famous mines of Golconda having meanwhile failed to repay the cost of working. Until a few years ago, the diamond mines of Minas Geraes, in Brazil, employed about 10,000 hands; but as the workings were free to all who chose to invest money in them, the supply appears to have become depleted, and for some time prior to 1870 they yielded but a very poor return.



KIMBERLEY CENTRAL DIAMOND MINING Co.

Section showing the Workings.

FIG. 1.

AFRICAN DIAMOND WORKINGS.

Since 1870 the Cape diamond fields have practically furnished the whole of the world's added supply. It is calculated that the total annual weight of Indian diamonds exported to Europe does not now exceed 100 carats, while Borneo annually furnishes about 3,000 carats more to the European market. The diamond mines of Brazil are stated to have supplied an average of 36,000 carats per annum between 1730 and 1814.* Between 1814 and 1845 the quantity fell off considerably; but between 1845 and 1860, again, it appears to have improved, the annual supply during this interval being returned at 40,000 to 45,000 carats.† Since 1860 the Brazilian trade has been a constantly declining one, and has now been practically ruined by the much richer deposits of South Africa.

There are several stories told by way of accounting for the discovery of the African diamond fields. One is that in the year 1867 a trader named O'Reilly, traveling southward from the Orange River, rested his oxen at a farm belonging to a Dutchman named Schack van Niekek, in the Hopetown district, and traced a diamond among a lot of beautiful Orange River stones on the table of the farmer. The diamond was ultimately sent to the High Commissioner, who took steps to prove its real character, and ascertained that it was a veritable diamond of 21¼ carats weight, and worth about £500.‡ Another story is that a trader, who happened to be passing through the Kimberley district, traced a diamond in the blue ground which was in the neighborhood of one of the farms, and thereupon instituted a search, which resulted in the discovery of the columns of ground which have since been developed into the richest diamond mines of either ancient or modern times.

However the truth may lie as to the original discovery of the existence of diamonds in the Kimberley district, certain it is that the fact of diamonds having been found in that district was no sooner made known than there was a great rush of diggers from different parts of the Cape Colony, and these were recruited later on by a considerable accession from other places farther afield. The original diggers limited their explorations to the Orange and Vaal rivers, especially the latter, on which there are said to be still some twenty or thirty mining camps. In 1870, however, the river diggings were largely abandoned for the farms of Dutoitspan and Bultfontein, where further discoveries of diamonds had been made, under conditions to be afterward described. The results for some time were not very encouraging. In 1871, however, a new digging was discovered on a farm called Vooriut Tugt, the property of an old Dutch farmer named De Beer. This soon turned out to be the richest diamond field in the world; and by a proclamation issued in 1874, it was converted into a series of mines, with the names of Dutoitspan, De Beer's, and Kimberley, to which, in 1882, the Bultfontein diggings were added. From these four mines almost the whole of the diamond supply of South Africa for the last fifteen years has been furnished.

At the Indian and Colonial Exhibition, in the South African Court, the local committee formed at Kimberley, for the purpose of regulating the diamond industry there, have erected a model of the last-named mine—the Bultfontein—whence a capital idea of the methods pursued in diamond mining may be obtained. The process differs in several particulars from those that have for so long a period been followed in Hindostan and Brazil. In Hindostan, according to Heyne, diamonds are only found in alluvial soil or in the most recent rocks. The stones are not scattered throughout the whole of these beds, but are confined to one that is invariably harder than the rest. The upper stratum, to the depth of 18 in., consists of sand, gravel, and loam. This is followed by a deposit of stiff black clay, or mud, about 4 ft. in thickness, after which comes the diamond bed, distinguished by a mixture of large rounded stones. This deposit is from two to two and a half feet thick, and is closely cemented together with clay. In this clay, shallow pits, only a few feet diameter, are excavated in such spots as the knowledge of the miner may induce him to select. If the results are not encouraging, the miner shifts his ground, but deep mining is scarcely known. In Brazil, the process of collecting diamonds is similar to that of mining for gold in alluvial deposits. The coarse gravel and rolled pebbles derived from the primary and metamorphic rocks form the lowest stratum among the sands and clays of the alluvium. This stratum is the repository alike of gold and diamonds.

The operations, however, are mainly carried on in the beds of the streams, from which the gravel is removed to be washed, generally in the rainy season. The deposit in which the Brazilian diamonds are generally found is termed by the natives *cascalaho*; it is an agglomerate, formed by the decomposition of the granite and mica-slate, and resembles some of the samples of diamond deposits of Hindostan in the possession of the Royal Society of Edinburgh. In Cape Colony, however, the diamonds are found in what are locally called "columns" of earth—these being, in Cape Colony, understood to be of igneous origin. In the case of the Bultfontein Mine, this "column" is about 250 yards diameter, outside of which there are deposits of shale, and other strata that contain no diamonds whatever.

The four great diamond mines of Kimberley are within intervals of a mile. The configuration of the country round about is remarkable, having all the appearance of a desert for about 150 to 200 miles in every direction. The greatest depth at which the diamonds have hitherto been found has been about 800 ft.; but it is not quite settled how much deeper the diamondiferous earth may reach. The Bultfontein Mine, of which a model is shown at the exhibition, is 300 ft. in depth, and about a quarter of a mile in diameter. In appearance it resembles a good-sized and exceptionally deep quarry.

The bottom of the mine is divided into little plats of irregular shape. The practice is to blast the rock by dynamite, the alluvium being treated by pick and shovel. The floors of the mine are a mile and a half long, and cover an area of 115 acres. The blue ground is broken up into small heaps or deposits, and removed in thimble-shaped wagons by a wire tramway to the depositing floors. Here the earthy matter in which the diamonds are found is allowed to remain for a considerable period, varying from three to six months, when the rays of the sun cause the ground to break up and disintegrate. In this condition, it is removed to the washing machines, where the diamonds are picked out as a result of separating themselves in the ordinary process of washing, from their great specific gravity.

The washing of the diamonds is an operation that has at the Cape been carried on until lately under great disadvantages. Water, to begin with, was for a long period exceedingly scarce, and had to be carried long distances. Hence, it was no unusual thing to find it sold at about 5s. per barrel. There is now a good

* According to Baron d'Eschwege.

† New American Encyclopædia.

‡ Noble's Handbook to the Cape of Good Hope, p. 179.

supply available at 1s. per 100 gallons. For this reason, more than any other, the earliest system of separating the diamonds adopted at Kimberley was that known as dry-sorting—that is to say, the excavated ground was sifted through hand sieves, whereby the finer portions were separated from the stones and coarse gravel, after which the latter was passed over a sorting table. It need hardly be added that this method failed to secure anything like the whole of the diamonds, and it is doubtful whether even one-half were recovered.

In 1874 the first washing machine was introduced. Structurally, it was a modification of the "cradle" employed in the river diggings, and consisted of an inclined plane on rockers, a number of transverse ribs across the plane arresting the heavier stuff, while the lighter ground flowed over the ribs, leaving the rough gravel behind them.

In 1875 the rotary washing machine, which is now employed at all the Kimberley mines, was introduced. This machine consists of a pan of 8 ft. to 14 ft. diameter, annular in shape, and closed by an outer and inner rim, the latter being about 4 ft. diameter, and not so high as the outer rim. In the center of the open space a vertical shaft rotates, and carries ten arms, ranged radially round the shaft, each arm having about half a dozen vertical knives or teeth, which are so set as to be within half an inch of scraping the bottom of the pan. The ground containing the diamonds is introduced into the machine through a series of inclined radial gutters, down which it is propelled by a stream of water, and is received in the large circular pan, where it is stirred up into a ripple by the revolving knives.

In this process the lighter stuff comes to the surface, and floats away over the top edge of the inner rim, while the heavier gravel falls to the bottom of the pan. The mud or "tailings," which flows to waste over the inner rim, is led by a chute to a pit, whence it is lifted by an elevator on to screens, over which the solid mud runs to waste, while the muddy water is led back by an overhead chute to the machine, to assist in forming a puddle of sufficient consistency to float the lighter stones in the pan, and allow only the heaviest gravel to settle at the bottom. An inclined cylindrical screen is fixed above the back of the pan, for the better mixing of this puddle, and the dry ground from the mine, having been tipped into the upper end of the screen, is met there by the muddy water from the elevator, along with a quantity of clean water, which allows of the larger stones, in which diamonds are seldom if ever found, rolling out at the lower end of the cylinder, while the puddle, carrying all the smaller stones with it, passes through the screen into the pan. The contents of this pan are, at the end of the day's work, emptied into an ordinary "cradle," or a small gravitating machine, called a "pulsator," in order to be cleaned, after which they are finally emptied on to the sorting table, where the diamonds are sought for.

The general custom at Kimberley is to examine this mud or puddle three or four times at least, in order that no diamonds may be missed; but even after this has been done, the stuff is removed by women to their homes, and carefully examined, with a view to the possible recovery of diamonds of more minute size, that are often found to have been overlooked. Some women are so expert at this sort of work that they are able to earn from 30s. to 40s. per week. The labor generally employed at the mines is native, and the wages paid varies from 15s. to 20s. per week.

There is no difficulty in obtaining an adequate supply of laborers; on the contrary, the supply largely exceeds the demand. About 20,000 natives came to the diggings during the first half of 1882, of whom 8,000 were Secocoeni's Basutos, 6,000 Shangans, 1,500 British Basutos, and 1,000 Zulus, while the remainder was made up of the representatives of sixteen other races and tribes. The greatest care is taken to prevent the natives from secreting diamonds. They are all searched for this purpose as they leave the mines, and a strong force of white men is kept on the watch to prevent communication between the natives and the white men outside, who are engaged in what is locally known as the i.d.b. (illicit diamond buying) trade.

Notwithstanding every precaution, however, it is estimated that diamonds to the value of about half a million sterling a year never reach the true owners, this being from one-fifth to one-eighth of the value of the legitimate trade. Of the four great mines at Kimberley, the richest hitherto has been the mine called after the district—the Kimberley.

In 1883, this mine yielded 947,817 carats, averaging a value of 17s. 10¼d. per carat, so that its total yield was worth not less than £846,705. In three and a third years ending December, 1885, the Kimberley mine yielded 2,494,985 carats, valued at an average of 19s. 3d. per carat, so that the total proceeds of the mine during this period were worth not less than £2,396,000. The value of the yield of the four mines, taken together—that is, the Kimberley, De Beer's, Bultfontein, and Dutoitspan—for these three and a quarter years was over 8¼ millions sterling. This amount would have been much larger, had not the value of diamonds fallen considerably in the interval.

These figures, however, do not represent the high profits that might be inferred at the first blush. The slips of the reef surrounding the diamondiferous ground have involved an enormous outlay on the part of the proprietors. In 1882, over half a million sterling was needed to defray the cost of the reef actually removed, and other slips were impending. At the end of 1882, ten million loads of solid and fallen reef, of sixteen cubic feet each, had been removed, at a cost of one and a half million sterling (excluding the further cost incurred in removing water and *débris*) in the case of the Kimberley mine alone, and a nearly equal quantity remained to be removed in order to allow of the mine being permanently safe for open working. The slips of reef have been a constant source of difficulty since the beginning. At the outset it was calculated that 60 degrees would be about the angle of repose. This, however, was found to be an error, and hence the figure was altered to 45 degrees, and now it is found that the angle must not be more than 30 degrees. The accompanying diagram (Fig. 1) shows a section of the working of the Kimberley Mine, and gives a good idea both of the geological character of the workings and their mechanical and physical features. The diamond-bearing rock which forms the mine is generally believed to be the funnel of an extinct volcano. It appears to be a hydrous magnesian conglomerate, with silica as a base. The diamond-bearing rock is believed to have been upheaved from a great depth. At about 100 ft. from the surface the diamondiferous earth, which had previously been of a soft, friable nature, and yellowish color, crumbling on exposure to the air, becomes harder, and slaty-blue in color. This discovery induced for a time the belief that the diamond-bearing ground was exhausted; but it was soon found that the blue ground was even richer than the yellow, and at the depth of over 600 ft. the blue ground has not materially altered, except in becoming harder and more crystallized.—*Industries.*

HIBERNATION: ITS PHYSIOLOGICAL SIGNIFICANCE.

THAT certain animals pass a large part of each year in a state of more or less complete quiescence and torpor is known to all, and little thought is commonly given to the matter; but it involves several points that are entirely antagonistic to those which are universally recognized as the established laws of vital action. They are worth careful study.

The state of torpor, often incorrectly called sleep, is in our climate associated with the winter season, and we call it *hibernation*, inferring that it is the result of cold, or that it is, at all events, dependent on low temperature in some way. But it is equally true that multitudes of species within the tropics experience precisely the same change on the occurrence of the dry season, with its burning heat, and lie torpid for an indefinite length of time, until roused into activity by the recurrence of rain. The state of torpor in their case is designated *æstivation;* and as the two are quite manifestly identical in their nature and action, we are forced to look to some other cause or causes for the condition than mere state of temperature.

Still again, a familiar case of hibernation proper may show us the same thing. A woodchuck of New England is in his state of activity only about five months of the year. In October he disappears from the upper world, goes down into his burrow, below the ordinary reach of frost, where he has already prepared for himself a snug and warm bed, rolls himself up into a compact ball, with his mouth and nose buried in the dense fur of his abdomen, through which it would seem almost impossible to draw a breath at all, even in the open air, instead of the narrow space of his confined chamber; and there he remains (and we have every reason to believe remains without starving) seven months more or less, as he does not show himself again before May. At the time when he went into his winter quarters he had scarcely felt any cold at all, for he goes down before frosty nights set in. It is safe to say that he will have been in his warm bed but a very short time before the air which surrounds him in his limited apartment will have a temperature nearer to 90° Fahr. than to 30°, and it is not probable that between that date and the next May it will ever be much below 60°. We must therefore almost entirely eliminate temperature from the list of causes to which we can refer his state of hibernation. And in support of this view it is but fair to recall the fact that most of our other wild animals remain in a state of activity throughout the winter, and are apparently but little disturbed by the greatest extremes of cold.

Our single illustration, thus far, has been selected from among the warm-blooded animals, but we could fill out our list, almost at random, from the cold-blooded; the frogs and toads for instance, tortoises, snakes, etc., though in their case the state of temperature seems to be more positively a determining cause. But with all, warm blooded or cold, the one predominating feature of the hibernation, from whatever cause it originates, seems to be a *suspension of vital action.*

This we argue from the fact that a continuance of vital action would necessarily cause its own destruction. And to make the case clear, it becomes necessary to rehearse a few facts in relation to the functions of nutrition and the laws which are connected with them; points which are thoroughly well established, though some of them are less clearly taught in textbooks than they should be.

1. The process of life is a process of constant waste and destruction, and as constant reconstruction. If either of these is arrested, or even disturbed, evil must ensue, and the nature or extent of the evil depends on which of the two is affected, and the degree and continuance of the disarrangement.

2. The sole agent in both cases is the blood, a fact perfectly known to some one as long ago as when Moses wrote "the blood thereof is the life." The blood is the builder and the destroyer. In its constant circuit it takes up the particles that have become waste and effete, and removes them, while at the same time it replaces them with equivalent particles vigorous and sound.

3. These changes are effected solely in the capillaries, and nowhere else. The arteries and veins have no function but that of conducting tubes. The blood in the most remote arteriole is as purely arterial blood when it enters the capillary as it was when it left the heart, as rich in life-giving power. The instant that it enters that tortuous, thin walled, short, and even calibered tube, it begins its work. It removes the waste cell of whatever tissue it traverses, and puts a living one in its place. The waste material it carries along with it, and is contaminated by it; and when it emerges into a vein it is no longer red, arterial blood, but instead of that it is dark, venous blood. Its work is ended; it does nothing more. It now contains effete material, which is poisonous to the system, and which, if allowed to remain and accumulate, will certainly cause injury, and, if its quantity grows by successive accretions, will cause death. As long as the capillaries continue this their normal work, the impurity thus imparted to the blood must be removed by the natural and normal modes of depuration, or death is absolutely certain within a very limited period.

4. The organs of depuration are chiefly three: the lungs, by respiration; the kidneys, by the separation of urea; and the liver. The failure of any one of them, or of all, to do the work assigned, causes cerebral oppression, stupefaction, and eventually death.

5. If the arterial blood be not sufficiently supplied with nutritive elements by the process of food digestion, while the capillaries continue their action, and the work of depuration is well performed, the tissues may waste away to an extreme extent, and yet death not ensue until after a very prolonged struggle.

These five principles are all that we need to consider in studying the strange features of hibernation.

If, then, we can assume or suppose a state of things to exist in which the functions of the capillaries are in large part suspended, the power of vitality still remaining, it is difficult to understand any reason why it may not continue to almost unlimited extent. The arterial blood which enters the capillary passes through it practically unchanged, the venous blood is no longer loaded with poisonous material, and no depuration is needed. The lungs find no carbon which must be removed in the form of carbonic acid gas, and respiration can shortly be reduced or even suspended without any oppression occurring as its result. The kidneys, finding no material for removal in the form of urea, can cease their action, and the brain feel no stupefaction from uræmia. No material is in the blood which must go as cholesterine, and the liver rests. The stomach needs no food, for the blood which is supplied to it is already rich and pure, having lost nothing during its course of circulation. The heart will continue its action, though very feebly, the bowels will cease to act, the temperature will necessarily be reduced, and, notwithstanding all this, there will be but little waste of tissue, that is, the animal will become emaciated in but a moderate degree.

These are the results which must follow such an arrest of capillary action as was suggested, and in specifying them we have described so completely the condition of a hibernating animal that it seems almost an inevitable conclusion that the *modus operandi* of hibernation is to be referred to this special change. The cause which induces it we must study separately, and singularly enough it will be in the line of human pathology instead of physiology proper, for not seldom diseased action, by its excesses and vagaries, may be our best guide in relation to that which is normal.

Turning now to current medical experience, we find frequent cases occurring of "hysterical unconsciousness," which present the following strange features, causing in their first appearing great alarm, for which there is really no occasion, since they are never fatal, and always terminate in recovery, even where no treatment is employed. They come from very slight causes, and commonly recur many times in the experience of the patient affected by them.

She drops off at once into a state of complete unconsciousness and insensibility, and remains so for an indefinite space of time, recovering her normal state as quietly as she lost it. During this continuance the circulation is but little affected, the pulse being slow and steady. The respiration is gentle, like that of a person in a deep sleep. The action of the kidneys is suspended, as well as that of the bowels. She, of course, takes no food. This condition continues for hours and sometimes for days, and is always so much time lost out of the patient's life history. When she "comes to," she goes on from the place where she stopped. She is not hungry, she is not thirsty, she is not exhausted, her brain is not oppressed. She may not have had a mouthful of food for days, and yet her stomach craves nothing more than though she had had her last meal at its regular time; and she is not aware that anything abnormal had occurred until she learns that she has had one of her "spells," as they are commonly designated. These cases are always of diseased action, and the only possible explanation of their features appears to lie in the assumption that the functions of the capillaries have been temporarily suspended. There has been no disintegration of tissue by absorption and removal of effete material, for none of it has been removed by the kidneys or the bowels, and but little by the lungs, and yet its accumulation in the blood is clearly contraindicated by the lack of its well-known effects. There has been no deposit of new tissue, or the stomach would necessarily have felt the exhaustion consequent on the lack of food supply. If the capillaries had gone on with their normal and customary action, it is not possible but that oppression, stupefaction, and exhaustion, always severe, and in most cases fatal, must have been the result. These attacks occur, in our experience, only in persons of a highly excitable, nervous temperament, mostly hysterical young women, and they are brought on in each instance by some depressing cause, that which exhausts the vital force and increases the nervous irritability, mental impressions taking the precedence of all others, though pain, shock, fatigue, etc., often do the work.

Religious enthusiasts of the highly wrought Oriental people have, in many instances, the power of throwing themselves into such a state at will, and remaining in it for a very long time. It seems very difficult to dispute the testimony which shows that a fakir was actually buried in a "trance" in 1837, his grave watched for months with extreme precaution against the slightest deception, and on exhuming him he was restored to vitality and health.

Now, it is not safe to say that these cases have any close alliance with hibernation, but they certainly simulate so closely the manifestations of hibernating or æstivating animals that we may deem ourselves warranted in assuming that the law of nerve currents which induces the one cannot be far removed from that which induces the other. And we found that in our medical experience this was, as a rule, a depression of vital force.

The question as to how long this suppression of capillary functions may continue, and yet life-power still remain, perhaps cannot be answered. Theoretically, it would seem that there was not necessarily a limit. Practically, we know that with our ordinary cold-blooded vertebrates, its normal duration annually is six or seven months, and that during this period the functions of vitality are suspended totally, not merely in part as with the warm-blooded animals. Frogs and turtles, for instance, hibernate at the bottom of muddy ponds, where, of course, respiration is to them impossible. Animals kept under the necessary conditions have been restored to full vigor at the end of years. Spallanzani's experiments go certainly to three and a half years. But if life can remain quiescent for that length of time, why may it not go on indefinitely—say for centuries. Certainly there is no proof that this may not be the case. The only point is that there is no good evidence of such actual occurrences. Many stories have been told of toads having been blasted out from granite, or slate, or sandstone quarries, but on investigation the proof has been wanting. The original story-teller had not had sufficient geological knowledge to be aware that toads had not yet come into existence on the earth

at the date of formation of the rock from which they were said to have been taken. There is a mistake in the toad or—or—somewhere. W. O. A.

ANÆSTHESIA THROUGH A MIXTURE OF CHLOROFORM AND AIR.

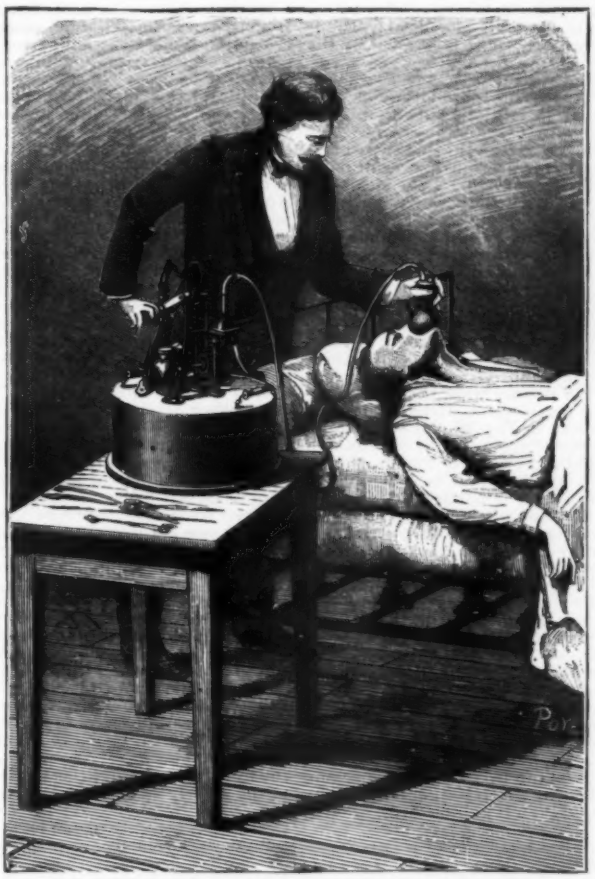
THE first operations (over two hundred in number) with Paul Bert's anæsthetic method were performed in the service of Dr. Pean. Other surgeons, too, Drs. Labbe and Lannelongue, at Paris, and Dr. Duplouy, at Rochefort, have successfully experimented with it.

Bert in the first place used two gasometers, which operated alternately, one emptying while the other was filling with air. This latter, in passing, vaporized the quantity of chloroform necessary for the desired dose.

This is a convenient apparatus for the laboratory, but for surgical use it presents the double inconvenience of being too bulky and of not allowing the proportioning to be easily effected. Moreover, the dose is measured by an assistant, and the intervention of man may lead to error.

Bert therefore requested various manufacturers to construct an apparatus that should embody these features, viz.: (1) to be non-cumbersome, not easily broken, and of easy management; (2) to be capable of effecting the proportioning of the mixture automatically; (3) to permit of easily changing the porportions; (4) to have no valve; and (5) to be so arranged that no accident could introduce too strong a dose of chloroform.

These desiderata are perfectly realized in an apparatus devised by Dr. Raphael Dubois, and constructed by



DR. DUBOIS' APPARATUS FOR PRODUCING ANÆSTHESIA.

Mr. Tatin. The annexed engraving will give an idea of how it is used.

It consists of a cylinder of 1,220 cubic inches capacity, whose piston is actuated by a wheel, connecting rod, and crank. Every time the piston, having reached the end of its travel, begins to drive out the 1,220 cubic inches of air, the parts that move it cause the alternate rise and descent of a small and very carefully graduated cup. This latter dips into an open bottle of chloroform, fills with the latter, and carries it upward and empties it into a funnel at the very point where the air is sucked into the cylinder. The air vaporizes the chloroform, and the proportioning is effected.

The machine then forces out the proportioned mixture continuously. A metallic mask is placed upon the face of the patient, who thus breathes in a current of chloroformed air, led by a rubber tube. The air escapes through an aperture in the mask; there is no valve. When it concerns operations upon the face or in the mouth, the patient is first put to sleep, and the mask is replaced by a metallic tube that runs to the pharynx. The anæsthesia may thus be continued indefinitely during the operation—a thing that is next to impossible with the compress. The chloroform cup is changed by one of the simplest of maneuvers.

Mr. Bert anæsthetizes his patients, whoever they be, with a mixture of 150 grains of chloroform vaporized in 3½ cubic feet of air. Anæsthesia is then obtained in 7 or 8 minutes at the most. When it is complete, the 150 grain cup is replaced by a 120 gain one. If the operation lasts more than half an hour, the dose is decreased, and anæsthesia is kept up with a 90 grain cup.—*La Nature.*

A CENTURY plant that for fourteen years has been in the Boston public garden is in bloom. The plant is not large, but the flower stalk rises fifteen feet into the air, and bears four clusters of yellow blossoms.

RECENT ADVANCES IN SANITARY SCIENCE.

"HYGIENE," in the words of the late Professor Parkes, "is the art of preserving health; that is, of obtaining the most perfect action of body and mind during as long a period as is consistent with the laws of life. In other words, it aims at rendering growth more perfect, decay less rapid, life more vigorous, death more remote." The art of preserving health is correlative with the science of prevention of disease, since perfect health means the absence of disease and of tendencies to disease. Hygiene is thus the art of preserving health and the science of preventing disease; and in taking into account recent advances in sanitary science, we must consider recent acquisitions in our knowledge of the origin, causes, and spread of disease, more especially of those diseases known as "preventable," as well as the methods of improving the natural conditions or social relations surrounding us, which are instrumental in preserving health and counteracting disease.

The etiological relations of all diseases are a subject of interest to the sanitarian, but those which have received the most attention of recent years, and in which the most striking advances of knowledge have either already been made, or are imminent in the near future, are perhaps Asiatic cholera, typhoid or enteric fever, diphtheria, and phthisis or tubercular disease of the lungs. The mode of origin and spread of Asiatic cholera has attracted great popular attention, both on account of its possible introduction into this country from infected districts of the Continent and from the alleged discovery by Koch of a *spirillum* or *comma bacillus* asserted to be the specific cause of this terrible disease. The Report of the Government Commission consisting of Drs. Klein and Heneage Gibbes, who visited India in 1884 with the object of undertaking researches into the etiology of Asiatic cholera, has lately appeared, and in this report the conclusions arrived at by Koch from his own researches are very directly traversed. This report, too, has received a very cordial support from a committee consisting of many eminent physicians and physiologists, which was convened by the Secretary of State for India for the purpose of taking it into consideration. It must be apparent, however, to any one who makes an impartial study of the literature of the subject, that, if Koch's organism has not yet been proved to be the actual cause of the disease, it has been proved to differ from all other organisms asserted to be identical with it, from the fact that its growth in various nutrient media is characteristic, and serves to distinguish it from all other organisms. As far as our knowledge at present extends, difference in manner of growth in nutrient media affords as just a basis for distinction between micro-organisms as difference of microscopical appearance or other morphological characteristics. Koch's comma bacillus is, therefore, diagnostic of the disease, and this fact has now placed in the hands of medical men the power of at once recognizing a true case of Asiatic cholera, the isolation of the organism from others in the choleraic discharges and its cultivation in suitable media being alone needed. The results of Koch's researches, whether fully accepted or not, have not affected, nor are they likely to affect, the measures on which reliance alone can be placed for the prevention of outbreaks and spread of the disease. In the words of the committee before alluded to, "Sanitary measures in their true sense, and sanitary measures alone, are the only trustworthy means to prevent outbreaks of the disease, and to restrain its spread and mitigate its severity when it is prevalent. Experience in Europe and in the East has shown that sanitary cordons and quarantine restrictions (under whatsoever form) are not only useless as means for arresting the progress of cholera, but positively injurious."

The view that typhoid fever cannot arise *de novo*, but is always propagated by a specific contagion from a previous case of the disease, is steadily gaining ground, as the number of epidemics where the disease has been definitely traced to specifically polluted air or water increases. In many other cases, although the specific pollution has not been definitely proved, the probabilities in favor of such a view have been very great. No micro-organism has yet been found which can lay claim to be regarded as the specific contagion of the disease; but we are in possession of so many facts concerning the mode of origin and spread of this disease, that any discovery of that nature would probably not greatly affect the measures now taken for its prevention.

The etiology of diphtheria has lately received very careful study, but so far without the attainment of any results capable of exact formulation. It is not a disease invariably dependent on insanitary conditions, such as typhoid fever is, but that such conditions favor its spread and severity is more than probable. The far greater comparative frequency of diphtheria in rural districts than in large towns in this country is well known, and has been attributed to the presence in the air of the latter of the products of coal combustion. This view appears the more probable, seeing that Continental cities, where wood and not coal is chiefly used as fuel, enjoy no such comparative immunity from the disease. Excessive moisture in the air of a house, whether arising from defective construction of the walls or roof, or from a waterlogged soil, are conditions very often associated with diphtheria. The fact also that the disease is most prevalent in the damper seasons of the year, when vegetable matter is undergoing decay and fungus life is most active, favors the theory that the specific contagium of this disease is a mould or fungus which flourishes most strongly in a damp and smokeless air. It is a remarkable fact that diphtheria is sometimes associated with scarlet fever in one epidemic, the two diseases appearing to be interchangeable; but this is a subject that requires further elucidation. The contagion of diphtheria is extremely persistent and long-lived, clinging with great pertinacity to infected articles, so that every article which is likely to have become contaminated requires very thorough disinfection, preferably by heat. There can be no doubt that school attendance is often a chief factor in the propagation of the disease among children.

Koch's discovery of the *Bacillus tuberculosis*, a micro-organism now proved to be the specific contagium of tubercular disease in men and animals, has placed tubercular phthisis in the category of contagious diseases. A peculiar disposition or tendency, whether hereditary or acquired, is no doubt wanted to enable the germ to take up its habitat in the human lung; but the fact that this idiosyncrasy can seldom be definitely recognized renders great caution necessary, both on the part of members of a family in their association with a consumptive relation, and of hospital authorities in admitting into a general ward cases of tubercular disease, or of massing together into one institution patients in every stage of the disease. The bacillus is constantly present in the sputum and probably in the breath of phthisical patients, and this points to the necessity of free ventilation of living and sleeping apartments, and disinfection of soiled articles of clothing and furniture. The external conditions which, of all others, cause a predisposition to consumption are a damp subsoil, causing excess of moisture in the air, and the constant breathing of an atmosphere vitiated by human respiration. It has been asserted that tubercle can be propagated from animals to man by the consumption of diseased meat, or, in the case of the cow, from the milk of a tuberculous animal. Further proof is required before we can accept such a hypothesis, but there is nothing improbable in such a mode of conveyance of the disease, especially in the case of children with a tubercular predisposition.

Besides the diseases which we now know to have been propagated through the agency of milk, enteric fever, scarlet fever, diphtheria, etc., in which the introduction of the morbid matter is accidental, the milk serving only as a means for its conveyance and perhaps for its growth, there is a complaint fairly definite in character, which has been attributed to the consumption of the milk of cows suffering from foot-and-mouth disease.

Here the morbid quality is inherent to the milk as taken from the cow, and is not due to an accidental introduction. The symptoms described in the epidemics recorded are fever, vesicular eruptions on the lips and in the throat and mouth, and enlargement of the glands of the neck. During the prevalence of foot-and-mouth disease, all milk taken by a household should be boiled before consumption. In view of the many dangers which threaten us through the agency of milk, it would perhaps be advisable, especially where children are the chief consumers, that this precaution should be always adopted; at least until the sanitary authorities in towns have the power of inspecting and controlling the farms and dairies in the country from which the chief part of the milk supply is derived.

The possibility of the transmission of the contagion of small-pox for considerable distances, not exceeding one mile, through the air has been warmly supported. There are many facts in favor of such a view, and its great probability will be seen from the following considerations. The contagion is almost undoubtedly a micro-organism of the class Bacteria, but as it has not yet been isolated and identified, we are unaware if it is capable of spore-formation or not. The spores of Bacteria can resist external agencies—heat, cold, drying, and antiseptics—to a much greater extent than the fully formed organisms; and it is probable that those diseases in which the contagion remains dormant for long periods are transmitted through spores capable of existing for long periods outside the body. But in small-pox it is not necessary to rely upon spore-formation to support theories of aerial transmission. The contagion as given off from the body of the patient is inclosed in minute epithelial scales and dry pus accumulations.

Here, protected from the air and from external destructive agencies, it may be wafted as a minute dust through the air, to descend at considerable distances. That the radius of infection from a small-pox hospital

as a center does not exceed a mile may be due to the great dilution of the contagion as it is diffused through greater distances than a mile from its center of origin, the hospital.

The observations of Dr. Miquel, at the observatory of Montsouris near Paris, have shown the number and variety of solid particles which are carried in the air, and the immense distances which some of them, as pollen and spores, may be presumed to have traveled. An educated public opinion will soon, if it does not already, regard small-pox hospitals as possible centers of infection, and will insist on their removal outside inhabited areas.

The compulsory notification of infectious diseases to sanitary authorities, either by the household in whose house the case occurs, or by the medical attendant, or by both, has been adopted in numerous provincial towns during the last five years. This measure has done much to furnish the authorities with early information of the occurrence of infectious disease which would not otherwise have been obtained, and such information has doubtless enabled the sanitary officials to stamp out many an epidemic in the bud which might otherwise have reached large dimensions. The more universal adoption of a measure of compulsory notification in our large towns is urgently needed.

In the domain of domestic sanitation the advances of recent years have been mostly limited to the practical applications of sound principles already acquired, to the carrying out of works of construction, drainage, or water-supply of the dwelling. Houses built for the use of the well-to do classes (not those of the speculative builder) in recent years will most generally be found to be planned and fitted on modern sanitary principles. Thorough ventilation of the drain and soil pipe, disconnection of the waste-pipes of baths, sinks, and lavatories, and of the overflow pipes of cisterns from the drainage system, are now understood to be necessaries of modern life.

A break in the connection between the house-drain and the public sewer by means of a manhole chamber and water-seal or trap, though not considered necessary or desirable by all, is now very usually practiced. We cannot doubt that the air of a public sewer is sometimes the means of disseminating disease, and any method which practically excludes such a source of danger from our houses is one to be encouraged. As knowledge extends, the simplest form of apparatus is found to be the best; many of the more complicated kinds of traps and contrivances for excluding sewer air are now discarded by builders and architects for those simpler forms which are equally effective.

In the matter of water supply, the belief is steadily gaining ground that a water once polluted by sewage cannot be regarded as safe for drinking purposes. Safe it may be so long as filtration on the large scale is efficiently performed, but any failure to thoroughly filtrate and aerate the water in times of epidemic visitation might be attended with disastrous consequences, even supposing that filtration through sand and gravel is destructive of disease organisms or their spores. The introduction of a constant supply of water into towns, in the sense that cisterns and receptacles for storing water are no longer necessary, has been of great benefit, especially in the poorer parts of towns, where water stored on the premises is usually highly contaminated.

Of the scientific witnesses who were examined before the Royal Commission on Metropolitan Sewage Discharge, nearly all were in favor of the principle of separation of the rainfall from the sewage. "The rain to the river, the sewage to the soil." In view of the ultimate disposal of the sewage, the advantages of the "separate method" are very great, and would now probably lead to its adoption in any new scheme of sewerage for a town where the circumstances are favorable.

From the public health point of view, it is also desirable to have impermeable pipe or brick sewers of small size, so that contamination of the soil by leakage into it of the contents of sewers may be avoided. In any such scheme of sewerage it must not be forgotten that not only are channels on the surfaces of the streets and roads required to convey away surface water, but pervious drains laid in the subsoil are absolutely necessary in the health interests of the town to keep the subsoil water at a permanently low level. For the disposal of the sewage, the value of a regular daily flow, and the elimination of the necessity in times of heavy rain of dealing with an enormous and uncontrollable volume of dilute sewage, must be obvious. The surface waters of towns are certainly not clean, but where the streets are efficiently scavenged they are free from taint of human excretal refuse, and fit for admission into the rivers, which nature intended as drainage channels of the surrounding high lands.

The extreme importance of thoroughly ventilating sewers is now very generally understood. Pipe sewers require as much ventilation as brick sewers, although the absence of deposit on the smooth internal surfaces of the pipes, and their consequent freedom from smell due to decomposition of deposited organic detritus, originally led to the belief that ventilating openings were not required in pipe systems of sewerage. It was not until Dr. Buchanan showed in the case of Croydon that the absence of proper ventilation in the pipe sewers of that town was in all probability instrumental in aiding the spread of enteric fever, that the opinion of engineers on this matter underwent a change. Displacement of air in pipe sewers of small diameter is greatly more sudden than in brick sewers of larger diameter; and it is plain, says Dr. Buchanan, that "means of such ventilation are wanted more numerously in proportion as the displacements of air may be local and sudden." Openings into sewers from the street level are still regarded as the best practicable means for the admission of fresh air and the exit of sewer air. Charcoal trays, Archimedean screws, and other contrivances for purifying the issuing air, or hastening its exit, are now generally abandoned as useless and inconvenient.

The purification and utilization of the sewage of towns is a subject of much importance, both in its public health and commercial aspects. The idea, so long entertained, that town sewage could by various methods be made to yield a manure which would give rise by its sale to an enormous profit is now exploded. The highest degree of purification, we now know, can only be attained on land naturally suitable from its porosity and other properties, and artificially prepared by extensive under-drainage. The agents which purify sewage in its passage through soil, by converting the nitrogenized organic matters into inorganic salts—nitrates and nitrites of the alkaline and earthy bases, and ammonia—have been discovered to be bacterial micro-organisms, resident chiefly in the superficial 18 inches of soil, and far more abundant in some soils than in others. Sewage farming has been ascertained to be profitable, under suitable conditions. The sewage must flow from the town to the farm by gravitation; the cost of pumping will neutralize profits from the sale of farm produce. A part of the farm must be laid out as a filter-bed, so that the sewage, when not required on the cultivated land, or when so dilute from the presence of storm waters as to be inapplicable, may be purified on a small very porous area by the process of intermittent downward filtration. Very few growing crops are benefited by the application of sewage, except the various kinds of grasses, and of these such enormous quantities can be produced that, unless converted into "silage," or utilized on the farm in the production of stock and dairy produce, they may be expected to result in a loss, from the absence of any demand for such large quantities at all periods of the year.

In this country the sewage farm at Birmingham is probably the best example of what has been done to solve a most difficult problem by the application of sewage to land. Here, the sewage is first freed from its suspended matters by a process of precipitation, a proceeding necessary not only to prevent warping of the land with offensive solid matters, but also to withdraw the metallic salts and acids incidental to the sewage of a manufacturing town, which would be injurious to vegetation. Even this magnificent example of dealing satisfactorily with the most difficult municipal problem of modern times is eclipsed by the city of Berlin, on the Continent. The sewage farms at Berlin have successfully dealt with the sewage of 887,500 people—nearly twice the population of Birmingham—while London is still allowing to run to waste an enormous amount of valuable material, at the same time polluting a river—the highway of its commerce—to an extent never previously dreamt of.

Processes of precipitating sewage by chemicals are now known to exert only a partially purifying influence. The best process yet discovered can do little more than free the sewage from its suspended matters, allowing all the dissolved constituents of sewage—by far the most valuable portion agriculturally and chemically—to pass away in the effluent. Lime dissolved as lime water, sulphate of alumina, and perhaps protosulphate of iron, taken together and added to the sewage in the proportion of not more than 10 to 15 grains to the gallon, are the best, most economical, and most effective precipitants. Other more valuable substances, added to the sewage with the view of increasing the value of the precipitated sludge or manure, are in large proportion lost in the effluent water, and, as they do not assist precipitation, might just as well be added to the sludge afterward, if fortification is required. Half a crown and no more is the value per ton of the precipitated solids of sewage. This value will generally pay for the cost of their carriage a mile or so in agricultural districts, but no farther.

A great improvement in dealing with the semi-liquid sewage sludge has been lately effected. The sludge containing over 90 per cent. of water was formerly allowed to dry in the air or in a drying chamber, and a most intolerable nuisance resulted. It is now possible by means of hydraulic filter-presses to convert the semi-liquid sludge into solid cakes, containing 40 to 50 per cent. of water, and in this form it is innocuous to the senses, and can be readily conveyed away by cartage.

The knowledge already acquired demands that now, and in the future, the sewage of towns should, whenever possible, be utilized on land in the production of crops or dairy produce; failing this, the sewage should be freed from its solids by precipitation, and subsequently purified on land laid out as filter-beds, efficient purification, and not the production of crops, being alone aimed at. If application to land is impossible, then precipitating processes alone must be relied on; and where the sewage can be turned into the sea, and effectually got rid of without nuisance, there it may be allowable to waste valuable matter which cannot be utilized except at a cost destructive of all profits from its utilization.—*Nature*.

THE MAKING OF MAN.

By CHARLES MORRIS.

FOR a period of many millions of years—how many not even conjecture can decide—the world of vertebrate life continued quadrupedal, the seeming deviations therefrom being rather apparent than real. Suddenly a true biped appeared. For a period of equal duration the mentality of animals developed with excessive slowness. Suddenly a highly intellectual animal appeared. The coming of man indicated, both physically and mentally, an extraordinary deviation from the established course of organic development. Both physically and mentally, evolution seems to have taken an enormous leap, instead of proceeding by its usual minute steps; and in the advent of the human species we have a remarkable problem, whose solution is as difficult as it is important.

It might be solved in a moment were we able to accept the arguments of those who hold that man is the outcome of a distinct act of creation, and is invested with powers and qualities, and prepared for a destiny, in which from the beginning he has stood apart from all other living beings. Yet these arguments no biologist of our day can accept. It has become clearly apparent that the points of distinction between man and the lower animals are simply of degree, not at all of kind, and that both physically and mentally man comes into close contact with the lower forms of life. They do not only touch, they are intimately interwoven. There is an intricate network of structural relations which binds man inextricably to the realm of lower life. This realm is not alone the basis on which he rests. It is the soil from which he has sprung, and into which he is so deeply rooted that not the hand of a god could tear him loose.

It is not our purpose here to give any of the arguments in favor of this conclusion. They may be found fully presented elsewhere. We design rather to endeavor to trace the line of ascent of man from the lower animal world, and to seek to discover to what combination of highly favorable circumstances his development is due.

Physically, man does not deviate very greatly from the mammals next below him. His method of locomotion is essentially changed, but structurally he is very closely related to the higher apes. Yet so much are all living beings the creatures of circumstance, that it seems possible, and even probable, that the remarkable mental differentiation of man may be a necessary result of this comparatively slight physical differentiation. His erect attitude, with certain variations in his life-habits which directly arise from it, bring him into new relations with surrounding nature, and these new relations have certainly very much to do with the new conditions which have arisen within him. A single step may lead at times to a vast train of unexpected consequences, and such seems to have been the case with this new step in evolution made by man.

Man is the only true biped. He has but two points of support, while all other animals are supported at four or more specialized points, or else rest on the general surface of the body. In birds, for instance, which are usually considered bipeds, the wings are organs for aerial support, and have no other function. The nearest approach to man in this respect, among existing animals, may be found in the forms which progress by jumping, such as the kangaroo. Yet in these the structure and function of the fore limbs is distinctly locomotive. And such was probably the case with the dinosaurian reptiles of a past geological era, despite the fact that they seem to have been able to walk, to some extent, on their hind limbs alone.

It is certainly remarkable that, in the whole extended period of animal life, no single vertebrate form appeared, so far as we can discover, before the advent of man, in which the fore limbs were completely freed from duty as organs of support and became structurally unfit for this duty. A partial freedom in this respect would be of minor value, since the formation necessary to locomotive duty must be retained, and the development of any new functional power would be checked. Thus in this respect man is an anomaly in the kingdom of life. And to this anomalous feature is quite probably due in very considerable measure the peculiar character of his development.

It is very evident, indeed, that the full adoption of the erect attitude gave man an immense motor supremacy over the lower animals; for it completely released his fore limbs from duty as organs of support, for the first time in the known history of vertebrate life. They were set free to be employed in new methods and to develop new functional powers, to which the grasping function, which man inherits from the ape tribe, was an invaluable aid. It is to the possession of two limbs which are freed from any organic duty other than attack and defense, and which are adapted to grasp weapons and tools, that man owes his enormous advantage over the lower animals. It opens to him possibilities which do not exist beneath him. All the forces of nature are at his command, as soon as he can learn to control them. The first club or spear he grasped, the first missile he threw, inaugurated a new era in the history of life, and opened the way to man's complete mastery. And, so far as we can perceive, this important structural advantage preceded the development of his mental superiority, and gave the cue to it.

In the vertebrate class below man, there exists but a single animal form that possesses a limb which is free from duty as an organ of support. This is the elephant, whose nose and upper lip have developed into an enormous and highly flexible trunk, with delicate grasping powers. The possession of such an organ has undoubtedly had its share in the marked intellectual development of the elephant. Yet this organ is far inferior in its powers to the hand and arm of man, while the form, the size, and the habits of this animal stand in the way of its gaining the full results which might arise from the possession of such an organ in connection with a better adapted bodily structure.

As to the evolutionary processes through which man gained the peculiar features of his structure, we have interesting evidence in the existing forms of life. In one type of life, and one alone, can we perceive indications of a gradual variation from the quadrupedal toward the bipedal structure. This is the ape type, or rather that of the lemurs and apes in conjunction. In all other mammalian types the aspect of the body is distinctively horizontal. Life in trees does not necessarily produce a deviation from this horizontal aspect, since it is retained by all arboreal mammals except those just mentioned. Yet it offers an opportunity for such a deviation, and this opportunity has been improved by the lemurs and apes. Their hands have developed a grasping power which is possessed by no other arboreal animal, and which opens to them new motor possibilities. They may assume a semi-erect or a fully erect attitude, by grasping upper branches with the hands. And this ability, in the higher apes, has led to the development of a mode of progression on the ground which is more or less intermediate between the quadrupedal and the bipedal modes.

This fact is of great interest, as it seems to lead us directly toward the development of the bipedal habit, as attained in man. Though such a habit may be partly attained by tree-living animals, a residence on the ground is essential to its full development. And it is significant, in this connection, that no existing apes have fully given up the arboreal habit.

Of the anthropoid apes, the orang and the chimpanzee dwell habitually in the trees. On the ground they are out of their true element. The same is the case with all the species of the gibbons. All these creatures move with some difficulty on the ground, but freely and easily in the trees. The gorilla, on the contrary, seems to dwell more habitually on the surface. Its great weight tends to render an arboreal life unsuitable, and its hand is not so well adapted to climbing as that of the chimpanzee. Yet it has only in part given up its arboreal residence. It ascends trees for food and, to some extent, to sleep, though there is some reason to believe that the adult males sleep occasionally, and perhaps habitually, on the ground. It seems to be in a transition state between the arboreal and the surface life-habit.

Of the lower apes, the baboons make the ground their usual place of residence. They have not lost

their climbing power, however, but can ascend trees with ease and rapidity. Most of the other apes dwell wholly, or nearly so, in the trees.

This fact of the partial or complete arboreal habit of all existing apes is of importance in this connection. It prevents any of them from attaining the peculiar structural development of man. The mode of progression best adapted to a life in trees is opposed to the erect attitude of man, and this attitude could not be fully gained except by a species which dwelt wholly on the ground. And life in trees absolutely requires the use of the arms as locomotive organs, and prohibits that freeing of them from this duty which exists in man. When man ascends trees, he is obliged to return to the habit of his ancestors and use his arms as organs of progression. It seems evident, therefore, that if man descended from the apes, his ancestral species must have been a form which had fully given up its life in trees, and had become almost as awkward in climbing as man now is, ere it fairly began to change from ape into man.

The adoption of a surface residence by any ape would necessitate certain changes in structure. Tree dwelling apes, when they descend to the ground, present us frequently with an awkward compromise between the horizontal and the vertical modes of motion. Neither of these modes is natural to them, and to become properly adapted to either, some change of structure is necessary. Many of them progress in the true quadrupedal manner, and in one ground-living tribe, the baboons, the structure of the body has suffered an accordant change. They have become true quadrupeds.

In other cases there is an inclination toward an erect mode of motion. Even among the lemurs this is occasionally displayed. Some species of these progress on the ground by jumps, the body being semi-erect and the arms held above the head. The anthropoid apes all have a curious mode of progression on the ground, intermediate between the erect and the horizontal methods. The orang, the chimpanzee, and the gorilla alike use their four limbs in progression, but in a manner very unlike that of ordinary quadrupeds. They swing the body in a curious fashion between the arms. It is a sort of half-jumping, half-walking motion. Resting the body on the hands, the animal swings itself between the arms, and moves forward by a quick succession of such lifts and swings. In this movement the orang and the chimpanzee bring their closed knuckles to the ground, but the gorilla is said to keep the hand open and apply the palm to the ground. The outer edge, rather than the sole, of the foot touches the ground. The whole movement is as awkward as is that of man when he attempts to climb trees, and seems to indicate that there can be no satisfactory compromise between the two life-habits. A surface-dwelling animal must tend to become either a quadruped or a biped.

The actual result in all these cases seems to depend largely on the comparative length of the arms and legs. All the three species named have shorter legs and longer arms than man, and can thus readily lift their bodies upon their arms while in a semi-erect attitude. Yet they all are obliged to incline the body forward in movement. This is less the case with the gibbons, the extreme length of whose arms enables them to reach the ground with the hands without bending the body. Thus the gibbons can walk on the four limbs with the body erect.

Certain species of the gibbon can readily walk erect on their legs alone by balancing themselves with their arms. They often do so, and can even move tolerably fast, the body rocking from side to side. But if urged to speed, they drop their long arms to the ground and progress in a swinging fashion. Of the other forms there is no satisfactory evidence that the orang ever walks erect, though it may be able to assume the erect attitude when attacked. Mr. Savage says that the chimpanzees are sometimes seen walking erect, the body bent forward, with the hands clasped over the occiput to balance. But on the appearance of danger they immediately take to all fours to flee.

The gorilla seems more inclined to walk erect, or rather in an inclined position, the body bending forward, with the head hung down. And it stoops less when on all fours than the chimpanzee, since its arms are longer. When walking, it balances its huge body by flexing its arms upward. Its gait is a rolling one, from side to side. When attacked, it seems to always assume the erect posture. In structural formation it is better fitted to the erect attitude than is the gibbon.

The subject here considered is of considerable importance in its relation to the evolution of man. We observe various phases of tendency toward the biped habit, and can readily perceive that the walking gibbons or the gorilla might in time become true bipeds if they should completely give up their arboreal residence. The length of the arms is an important element in this problem. In all the species mentioned the length of the arms differs, but in all it is longer, as compared with the body and legs, than in man. The species from which man descended, with its longer legs and shorter arms than in the existing anthropoid apes, could not, without the greatest difficulty, have adopted their swinging mode of motion. Nor could it advantageously have assumed the quadrupedal habit, as in the baboon, whose four limbs are nearly equal in length. It was forced toward the bipedal habit by sheer necessity. On taking the ground surface for its place of residence, it was probably obliged to walk erect as the only movement to which its structure was well adapted. Neither the quadrupedal nor the semi-quadrupedal movement would have been suited to the proportions of its limbs, and its ancestral movement in trees may have been more vertical than is common with apes. Its bipedal development may have begun while it was still arboreal.

This erect posture once fully assumed, and the arms thus completely freed from duty as organs of support, the animal, yet an ape, would have had an advantage of the greatest value over its fellow apes, and over all other members of the animal kingdom. Nearly all quadrupeds use their limbs to some extent in attack and defense. Yet the necessity of resting on these limbs interferes to a certain extent with this duty. In the animal in question, the duty of locomotion being confined to the hind limbs, the fore ones were completely set free to be used as weapons. And to this power was added that very important one of their peculiar adaptation to grasping, which enabled the creature to add greatly to its natural stength by the use of missile and other weapons.

This advantage has not been confined to man and his progenitors. The power of the grasping function in this direction is of service to many of the apes. The story of the cocoanut-flinging monkeys does not need to be repeated. And it is equally well known that the orang, when attacked, will break off fragments of branches and shower them to the ground in a rage. But in all such cases there is nothing to indicate any precision of aim. The throwing seems to be done at random. It is probable that the arm has to be educated to the proper use of missiles, and that to gain this function it must be freed from other duties.

There is no positive evidence that any apes use weapons except in this manner. The story is told that the chimpanzee will wrest the spear from the hunter and use it against him. But this story needs to be verified. Also the common picture of the orang walking erect and supporting itself with a staff is entirely imaginative. Nothing of the kind was ever seen in nature. The teeth seem the main dependence of these creatures for purposes of defense. They will break off limbs and twigs and make themselves beds with great rapidity, but this seems the utmost limit of their constructive powers.

As for the animal from which man descended, it must have quickly gone further than this in the use of artificial weapons and in the arts of construction. Possibly its first assumption of the erect attitude may have been aided by the use of a staff, and if so, this would naturally be employed as a club or a spear on occasion. Through uses of this kind the arms would gradually become educated to their new duties, and gain facility in important movements which were impossible while they were forced to retain their locomotive adaptation.

This line of argument need not be carried further. It is evident that we have here the beginning of a new course of development whose end is yet in the future. The freedom of the arms and hands from the duty of support, their grasping power, and the use of artificial weapons and tools, were unquestionably main elements in the evolution of man. For under such circumstances the employment of artificial instruments would naturally be progressive. There would be no limitation to this progress from the necessity of using the arms for other duties, and such structural limitation as may have originally existed must gradually have disappeared through increasing performance of and growing adaptation of the arms and hands to these new duties. The use of clubs in attack and defense, and of stone missiles for the same purposes, might readily have been adopted by an ape so constituted, and modern archæologists do not hesitate to trace all subsequent development in the arts to just such a simple beginning. Rudely chipped stones are found as early weapons of primitive man. Naturally shaped stone weapons undoubtedly preceded them.

Whether one or more species attained this bipedal development is a question not easily settled. It is almost certain that there was one only. Yet, if so, variations in the structure of this original biped must have taken place at an early date, possibly ere it became a full biped and began to strongly resist the moulding influences of nature, if we may judge from the essential structural differences between the principal races of mankind.

Yet highly favorable as was the structual development of the original man, it needs no extended consideration of the subject to perceive that in this we have but one of the factors to which he owes his supremacy. The freeing of the arms to the performance of new duties was an essential agent in any rapid mental development. Yet it was not the only agent. The mental development of man began in the mental development of the apes. It is but the completion of a process which extends much further back than the beginning of the human era, and through which, in one type of life, the mammalian intellect attained an exceptional unfoldment. Human mental progress began at the high level attained by the anthropoid apes. To the causes of the unfoldment of the ape intellect some attention is therefore due.

There is nothing in an arboreal residence in itself to specially promote mentality. The squirrels and other arboreal quadrupeds are not of a high intellectual grade. Undoubtedly the activity, the variety of motions, and the grasping power of the monkeys must have aided in their mental unfoldment, yet we find that the lemurs, with the same general organization and life habits, are intellectually dull. For the inciting element to the development of the ape intellect, therefore, we must look further.

Among the lower life forms, the carnivora are more intellectual as individuals than the herbivora. Yet as groups the latter occasionally display intellectual conditions far higher than anything attained by the solitary carnivora. These instances of intelligence are only found among the social species, and are displayed most remarkably in the communal classes, the ants, bees, and beavers.* Yet even in these the purely plant-feeding bees fail to display the great variety of intelligent acts of the partly carnivorous and actively belligerent ants. It would appear, therefore, that while the activity and cunning arising from carnivorous habits aid in the development of individual intelligence, it is equally aided by social habits, and that a combination of these two requisites presents the most favorable condition for high progress in intelligence.

In fact, if we consider fully the ants, we find that these minute creatures, with none of the advantages in structure over their fellows possessed by man, have advanced politically and industrially to a level which was not reached by man until after he had dwelt for ages upon the earth. And, so far as all indications point, this exceptional development is due to social or communal influences alone. It appears, therefore, that social combination is a highly essential agent in intellectual development, quite as important as, perhaps more important than, any special advantages in structure and individual habits.

The solitary life of cats, spiders, etc., while aiding to develop mentality in individuals, prevents the transmission of useful ideas. Only instincts are transmitted. Ideas die with their originators. On the other hand, the communal habits of ants and bees, while highly adapted to the preservation of useful ideas, tend to hinder individual excursions of mind and the rapid growth of ideas. An ant community is a society of strict specialists. The best condition for intellectual progress would seem to be an intermediate one, in which complete individual activity exists, yet in which social links are closely drawn, so that ideas may be transmitted by education and observation, as well as instincts by heredity. And to the fullest utility of this condition some degree of carnivorous habits would seem essential. It needs no intellectuality to gather fruit from the trees. It needs often the highest exercise of cunning to capture animal prey, while it produces a variety of perilous and exciting situations to which the strict vegetarian is not subjected.

Among modern apes socialism exists in various degrees. The lemurs display but little socialism. Some species of monkeys display it in a high degree, and it is a general characteristic of the family. Mutual aid in danger is common, education is not wanting, combination in enterprises is frequently observed, and probably through these and the like influences, observation and imitation have been developed to a degree not seen elsewhere among the mammalia. Yet so advantageous is social combination in promoting intelligence, that the high degree of cunning displayed by baboons, in posting sentries while robbing fruit plantations, is but a fuller development of a similar habit possessed by several species of otherwise dull social animals.

Among the existing anthropoid apes, however, the social habit is greatly lacking. The orang, the chimpanzee, and the gorilla are more or less solitary in their habits. The orang is particularly so, and is never seen in groups of more than two or three. The chimpanzee and the gorilla are somewhat more social, yet not markedly so. The groups of the gorillas appear to be polygamous bands, since they never possess more than one adult male, the rest of the band being composed of females and young. There is more evidence in favor of the chimpanzees combining in larger groups, yet this does not appear to be their usual habit. Reade remarks that both these species, without being gregarious, sometimes seem to assemble in large numbers. Unfortunately, very little satisfactory information is possessed as to their habits in a state of nature.

These large apes are also strictly vegetarian. They lack the incitement to intellectual development arising from carnivorous habits. On the whole, then, their marked powers of intellect are somewhat surprising. It is probable, if we judge from the habits of the lower monkeys, that the anthropoids descended from social species, and have in part lost their social habits. This is also indicated by the fact that the young of these anthropoid apes seem more inclined to socialism than do the adults. It is also shown in the higher socialism of the gibbons, the existing representatives of the primitive anthropoids.

If we seek, then, for the ancestors of man in the family of apes, we must look for a species possessed of several essential requisites, all of which can be found in no existing apes. These requisites, as considered in what precedes, may be briefly summarized.

The ancestor of man must have been of sufficient size and weight both to render continued life in the trees inconvenient and to give the necessary strength to combat with the perils of a surface life. His strength, indeed, must have been sufficient, combined with his cunning, to make him a match for the larger animals. He must have been aggressive as well as defensive, and if not originally carnivorous, must have become so in a degree. Strictly herbivorous habits would have tended to check mental development.

Second, and yet more important, was the assumption of an erect attitude, and of a true biped structure, with the complete freeing of the fore limbs from duty in locomotion. There naturally followed upon this an increase of that use of missiles already possessed by the apes, with an advancing skill in the use of artificial weapons as the arms became adapted to this new function. With this came that dominance over the lower animal world which has been so essential a feature in the progress of man. And with it began his still increasing control of the energies of nature.

To these physical conditions must be added the social one. The ancestors of man could not have been solitary in their habits, but must have been strongly social. It is possible that the solitary condition of the existing great apes is the result of their strictly vegetarian habits. An anthropoid with carnivorous tendencies and original social habits would tend to increase rather than to lose these habits, through the great benefit derived from mutual aid in conflicts with the larger animals. That man, at an early period in the stone age, waged war with the largest animals, we have satisfactory evidence in the results of archæological discovery.

The original human society must have been one of mutual aid, combination in enterprises, some degree of language, or of the use of sounds conveying warning or information, protection and education of the young, and habits of observation and imitation. All these exist in some tribes of monkeys. As to vocal powers, the gibbons possess them in a high degree, though there is no evidence to show that any existing apes have specialized sounds to convey special information. It is to a group of the higher apes which possessed these characteristics in an unusual degree that we must look for the ancestors of man. If we be asked for traces of such a group, we can but point to man. The ancestral line has vanished in that of its descendants. The existing anthropoid apes are but side issues in the problem.

The development of the social condition and of the educational process must have had a vigorous influence in the enlargement of the brain. In man the dividing line between the physical and the mental powers, as organizing agents, was finally passed. A tribe had arisen, for the first time in the long history of animal life, that trusted more to its mind than to its muscles, and which had begun to substitute artificial for natural tools and weapons. With the attainment of this condition there was taken the first decided step in that long line of mental progress which has produced the brain of man. In all preceding ages evolution had been mainly physical, and exerted its chief influence upon the limbs and muscles. Now, for the first time, mental evolution gained the supremacy, and development centered itself in the brain, the organ of the mind,

* See Communal Societies, *Popular Science Monthly*, Jan., 1886.

while the body, in great measure, ceased to change. Under these circumstances, there is nothing very surprising in the fact that the human brain has attained an exceptional development, or that its growth was strongly marked at a very early date. How far it has increased in size over that of its non-human ancestor, we cannot judge from comparison with the brains of any existing apes, since these may be of a much lower grade of development. They are probably not fair standards of comparison. And if the body stood almost unchanged for ages, and all the influences of nature centered themselves upon the brain, a considerable increase in size and some variation in structure were inevitable consequences, and it is not easy to perceive, under the circumstances, that there is anything extraordinary in the special growth of the human brain.

In the making of man, then, we perceive the critical step that took the animal world over the dividing line between physical and mental evolution; and in human development we are concerned, not with the maturity of an old, but with the infancy of a new evolutionary process, which is full of far-reaching and extraordinary possibilities, of which the intellectual progress yet attained by man may be but the beginning. There may be needed as many millions of years for the full development of the mind as have been consumed in the evolution of the body, and the organ of the mind may yet attain an importance in the scheme of the physical organism of which we have no conception.—*American Naturalist.*

SACCHARIN.*

By L. WOLFF, M.D.†

UNDER this name a product of the coal tar derivatives has been recently introduced for medical use. It was first produced by Dr. C. Fahlberg in 1879, who described it, together with Prof. Ira Remsen, in vol. i., page 426, of the *American Chemical Journal.*

To understand the chemistry of saccharin, it is necessary to enter somewhat into the consideration of the aromatic group of hydrocarbons from which it is derived.

This series is known by the general formula of C_nH_{2n-6}; *i. e.*, every member of the group contains for the carbon atoms twice as many of hydrogen less six. The starting point of this is benzene, C_6H_6, derived by distillation from coal tar, and the second member toluene, C_7H_8, or methyl benzene, also written as $C_6H_5.CH_3$, another distillate from that source.

Toluene treated with sulphuric acid, H_2SO_4, so that the H adjoining the CH_3 in the hydrocarbon chain will be substituted by SO_2H, yields orthotoluenesulphonic acid, expressed by the formula $C_6H_4.CH_3.SO_2H$.

This converted into orthotoluenesulphochloride, $C_6H_4.CH_3.SO_2Cl$, and treated with ammonia, NH_3, gives orthotoluenesulphamide, $C_6H_4.CH_3.SO_2.NH_2$.

As toluene by oxidation is changed into benzoic acid, so is the toluenesulphamide changed when oxidized with potassic permanganate, $KMnO_4$, into benzoic sulphimide, or saccharin, and orthosulphobenzoate of potassium. This mixture, when treated with hydrochloric acid, HCl, leaves a precipitate of benzoic sulphimide, $C_6H_4.CO.SO_2.NH$.

This benzoic sulphimide, if treated with water, gives orthosulphaminbenzoic acid, $C_6H_4.CO_2H.SO_2NH_2$, so that saccharin may be therefore properly termed an anhydroorthosulphaminbenzoic acid.

Saccharin, prepared in this manner, is a white powder, composed of irregular crystals. It is very slightly soluble in water, not quite half per cent. dissolving at ordinary temperatures, while it dissolves readily in warm and boiling water, from which it crystallizes out on cooling. As forming sulphaminbenzoic acid when so dissolved, it has an acid reaction. It is readily soluble in alcohol and ether. Its salts, with the hydrates or carbonates of the alkaline metals, are readily soluble, but saccharin is separated out from such solutions on the addition of acids. Heated to 220° C. it melts, and is partially decomposed, and, when fused with potassic hydrate, it forms salicylic acid. Its most remarkable property, and that which makes it of advantage to medicine, consists in its intense sweet taste, which is so great that one grain, if dissolved and neutralized in about ten pints of water (1 to 70,000), can still be tasted, while one grain of cane sugar can only be detected at the utmost when dissolved in half an ounce of water, so that saccharin is about three hundred times sweeter than sugar, the taste of which it represents entirely in quality. Professor Mosso has recently studied the physiological effect of saccharin, and published the results in the *Archivo per le Scienze Mediche*, vol. ix., 1886. According to his researches, it is not, like benzoic or salicylic acid, excreted in the urine as hippuric or salicyluric acid, but is found therein in the same chemical condition as ingested. Frogs can be kept indefinitely alive in a neutralized watery solution of saccharin. When injected under the skin, the urine tastes sweet within fifteen minutes, and continues so for several days. Experiments with dogs, when saccharin is given in large doses, developed no impairment of nutrition, nor was during its use the amount of urea eliminated either increased or diminished. The urine of animals fed with saccharin is less prone to putrefaction. The amount of chlorides in the urine is increased during its use, while the phosphates and sulphates remain normal.

Animals on full diet, along with saccharin, increase in weight. On man, doses of 5 grammes (75 grs.) produce no abnormal effect, and the appetite is stated to be increased during its use. The uropoietic ways are the only eliminative tract for saccharin, which makes itself manifest in the urine half an hour after its ingestion. It may be summed up, therefore, that saccharin is not possessed of any toxic or deleterious effect on the human organism.

In therapeutics this new substance is destined principally as a corrective for the taste of other substances, and as a condiment for the use of persons suffering from diabetes mellitus and those under treatment for the reduction of obesity.

In several experiments that I have made, I found it to correct the bitter taste of quinine materially if one part of it is added to two parts of the latter. As its solution forms an acid, which readily forms salts with bases, it can be utilized to combine directly with alkalodial quinine to form a quinine sulphaminbenzoate.

In fermentative disturbances of the digestive tract, when sugar and carbohydrates are contraindicated, it may be used as a corrective for the nauseant taste of other remedies, especially so as it has decided antiseptic powers. It may also be used as a condiment for milk and other nutriments to be taken. To improve the taste of elixirs, wines, etc., it seems especially fitted, as they will under such conditions have the very desirable property of not deranging the stomach. The coffee and tea of diabetic patients may be sweetened with a grain or two of saccharin, and it may also be added with advantage to jellies and other foods for such patients.

That saccharin has a place in medicine and in the dietary list is undoubted, and that it is innocent in its effect commends it especially to a trial by physicians. —*Therapeutic Gazette.*

* Read at the Clinical Meeting of the Philadelphia County Medical Society, May 19, 1886.

† Demonstrator of Chemistry, Jefferson Medical College.

SOLUBILITY OF SULPHUR.

IN the SCIENTIFIC AMERICAN SUPPLEMENT of May 22 appears an article extracted from the *Chemical News*, in which Mr. Bloxam makes mention of the solubility of sulphur in alcohol, and says he was unable to find, except in one author, Miller, "Inorganic Chemistry," any authoritative saying on the subject. His discovery was made while operating with alcohol upon sulphur and fatty matter. He found that crystals of sulphur had been precipitated. It is not mentioned what proportion of sulphur had been obtained. He says the important bearing of the subject is in relation to the use of rubber corks with alcohol. If he had consulted Pagen, vol. i., p. 127, 5th ed., of Paris, 1867, he would have found good authority on the subject. The solvents given are as follows:

	Solvents, hot.	Solvents, cold.
Sulphide of carbon	72·46	38·70
Essence of coal tar	26·98	1·51
Benzine	17 04	1·79
Spirits of turpentine	16·16	1·30
Naphtha	10·36	2·37
Carbolic acid	5·47	0·66
Ether, pure	0·54	0·18
Alcohol, anhyd	0·42	0·12

It will be seen by these figures what a small proportion of sulphur is susceptible of solution, in hot alcohol 42 hundredths of 1%, and in cold 12 hundredths of 1%. When it is considered that a very small part of the cork is in contact with alcohol, the quantity of sulphur dissolved would be almost inappreciable. Mr. Bloxam is nevertheless entitled to the merit of the discovery, although the discovery had before been made. He should have given particulars of proportion, essential in science. It is merely possible that certain combinations of sulphur would be acted upon differently.

J. C. DELAVIGNE.

THE NITROGEN OF THE ATMOSPHERE AND OF THE SOIL.

MM. BERTHELOT and André have contributed to the *Comptes Rendus* several communications relating to M. Berthelot's observations upon the direct fixation of free nitrogen by clayey soils—a process which has been shown to depend upon the presence of certain living organisms which seem to belong to the order *Diatomaceæ*. The first of these articles refers to the attempts made by M. Berthelot to find some means of ascertaining the proportion of these active organisms present in any particular sample of soil. It has not yet been considered possible to isolate the organisms; but an idea may be gathered respecting their abundance by valuation of the carbon constituting their tissues. This estimation has been made by the ordinary methods of carbon determinations; but the operation is very delicate, and the results are liable to be affected by many disturbing influences which have to be allowed for. After many experiments, however, and taking everything into account, M. Berthelot has been led to consider that 1 kilogramme of the various soils which are capable of fixing the nitrogen of the atmosphere will contain from 1 to 2 grammes of organic matter, which constitutes the substance of the organisms which cause this effect.

In another communication, the authors point out that soils containing ammonia lose a proportion of it in drying. It is concluded that soils wetted by rain or by watering tend to lose ammonia during their drying in contact with the air; they give up ammonia to the air, and they also take ammonia from it. There is thus a mobile equilibrium between the air and the soil in respect of their exchanges of ammonia. In a third communication, the authors deal with the estimation of ammonia in rain water, which should be effected with precautions which they describe, in order to ascertain the total proportion of nitrogenous matters brought down by the rain and snow to aid in fertilizing the soil.

NEW ELEMENTS IN GADOLINITE AND SAMARSKITE.

PROF. WILLIAM CROOKES, F.C.S., says, apropos of the recent announcement by M. De Boisbaudran of the discovery of a new element, dysprosium, that he, in investigations still incomplete, had come across the line in the spectrum that distinguishes more especially this element. He had, he says, deferred his investigation of the meaning of the line, ignorant of M. De Boisbaudran's studies, and so possibly lost the glory of discovering the new metal. The paper here referred to was read before the Royal Society, June 10, 1886. Prof. Crookes, in the course of his remarks, emphasizes the value of his radiant-matter spectroscopy. Certainly some of the points in its favor are very strong, especially the fact that the sample is not destroyed, as it is only the emanations of phosphorescence that are analyzed in the spectroscope, not the light furnished by the ignited vapor of the metal or its compounds. The probability is held out that more metals are yet to be discovered in these two minerals. They threaten to be one of the most fertile fields of discovery that have ever been worked up since the early days of chemistry. Prof. Crookes thus eloquently speaks of his method of spectroscopy:

"The radiant-matter test for these phosphorescing bodies proves itself every day more and more valuable, as one of the most far-searching and trustworthy tools ever placed in the hands of the experimental chemist. It is an exquisitely delicate test, capable of being applied to bodies which have been approximately separated, but not yet completely isolated, by chemical means; its delicacy is unsurpassed even in the region of spectrum analysis; its economy is great, inasmuch as the test involves no destruction of the specimen; its convenience is such that any given test is always available for future reference; and the quantity of material is limited solely by the power of the human eye to see the body under examination. Beyond all these in importance is its trustworthiness. I should be exceeding the legitimate inference from experience were I to say that the test is infallible; but this I may say: During the five years in which this test has been in daily use in my laboratory, I have never once been led to view its indications with suspicion."

The trouble involved in the sealing up of the substances in high vacua may easily be simplified as the demand for this species of investigation increases; and it may yet find very extensive application in every-day chemical work.

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